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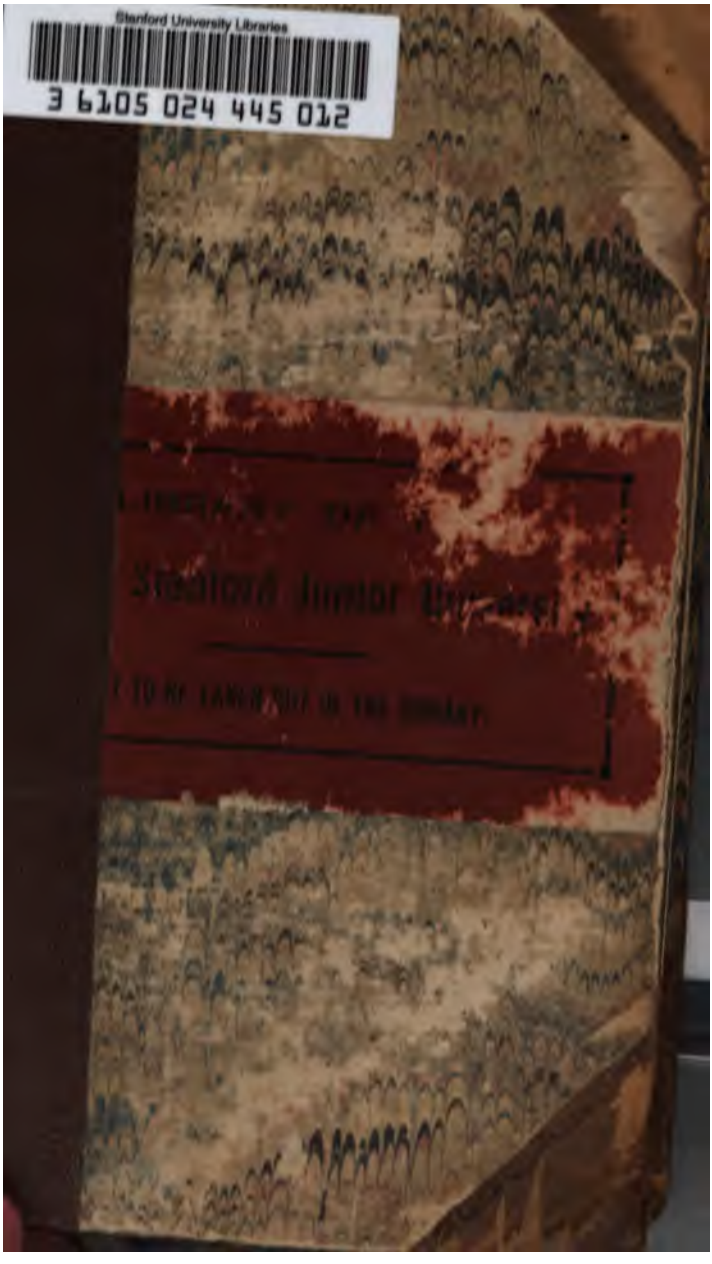

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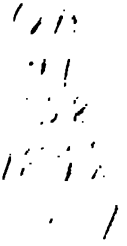

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ADVERTISEMENT.

In introducing this small work to the notice of the Public, the Author has merely to state that it was undertaken with a view to facilitate the calculations of Millwrights, Engineers, Ironfounders, &c., and by them it is to be hoped it will be duly appreciated, more especially when they consider that the subjects treated of (with very few exceptions) have been diffused throughout a number of valuable and extensive works, quite out of the reach of mechanics in general, and too voluminous to be made useful where they were most required. Indeed, the greater part of mechanical works have been swelled out by theoretical problems, too tedious for practical men,—a defect which is here obviated, by commencing with a system of decimals, and carrying on the work throughout entirely on that system.

With regard to the subjects selected, no comment is necessary, as every mechanic is well aware that one or other of them is required daily; and the reader will find the book, though small, to be interspersed with various original and useful rules, well adapted for mechanical calculations.

Liverpool, July, 1832.

ADVERTISEMENT TO THE SECOND EDITION.

It is, undoubtedly, a source of gratification to an author to find that his labours have been duly appreciated by a discerning public; and this, it may be inferred, has been the case with the Author of the "Millwright and Engineer's Pocket Companion," the first edition having been disposed of in little more than twelve months; and a second edition being called for, he has been induced carefully to revise it, and greatly to augment it with other useful matter;—among which will be found, Tables of Square and Cube Roots, Strength of Materials, Tables of the Circumferences and Areas of Circles, &c.,—hence it is anticipated that these improvements, combined with the former practical rules which it contains, will render it a still more useful companion to mechanics, and men of business in general.

Liverpool, September, 1833.

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The object of this work is to combine (in as small a compass as is compatible with the importance of the various subjects it embraces) and to facilitate the daily calculations of Millwrights, Engineers, Ironfounders, and Mechanics in general; hence, correctness is the basis of its claim to merit. The Author, being aware of this, and finding, in a great measure, that his labours have met his expectations, by the rapid sale of two editions, has been induced to revise the work throughout; and where personal experiment and practice have overthrown old rules, to introduce new ones, in accordance with the most celebrated machinery: being aware, also, of the general application of decimal arithmetic to mechanical calculations, he has been induced to commence the work with its principal leading rules, and to form each succeeding rule and table upon that system.

Several very important rules have been added, and various rules of not so much importance made approximates, by which the work will become more generally useful, and, at the same time, not more bulky, so that it may still retain the name of a useful Pocket Companion.

November, 1835.

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May, 1839.

... THE SIXTH E

... work are best appreci ... unremitting demand; c ... considerable share. ... of leaving still ... render it of ... more deservedly ... previously ... carefully examining ... purpose of cor ... might have crept in ... errors and omissions but also ... portion of new m ... been obtained through the advancement ... since the work was first in ... public favour.

... information wh ... has now ... discovery and investigation, has thrown new ... work in the former considerably improved. ... work as a great national undertaking, s ... pace with the vast ... of that ... of science to which it professes to belong ... presumed, in consequence of the great care ... been bestowed in the revision of the wo ... quantity of practically useful matter adde ... found not only to support the character w ... already attained, but that its value will be ... enhanced in the estimation of the public.

... 1841.

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THE

MILLWRIGHT AND ENGINEER'S

POCKET COMPANION.

AN EXPLANATION

OF THE SIGNS OR CHARACTERS NOW GENERALLY MADE USE OF IN ALL SORTS OF CALCULATIONS.

$=$ signifies Equality, as.....4 added to 3 is equal to 7.

$+$ signifies Addition, as..... ..... $5 + 3 = 8$.

$-$ signifies Subtraction, as ..... $5 - 3 = 2$.

$\times$ signifies Multiplication, as .... $5 \times 3 = 15$.

$\div$ signifies Division, as .....$15 \div 3 = 5$, or $\frac{15}{3}$.

$:::$ signifies Proportion .....as 2 is to 3, so is 4 to 6.

$\surd$ signifies Square Root, as .....$\surd 9 = 3$.

$\sqrt[3]{}$ signifies Cube Root, as .....$\sqrt[3]{27} = 3$.

3^2 signifies that 3 is to be squared, as..... $3^2 = 9$.

3^3 signifies that 3 is to be cubed, as ..... $3^3 = 27$.

$\overline{3 + 5 \times 3} = 24$ the Bar signifies that two, three, or more numbers are to be taken together, as 3 added to $5 = 8$, and 3 times $8 = 24$.

$\surd \overline{5^2 - 3^2} = 4$ signifies that 3 squared taken from 5 squared, and the square root extracted $= 4$.

$\sqrt[3]{\frac{\overline{20 \times 12}}{30}} = 2$ signifies that when 20 is multiplied by 12, and divided by 30, the cube root of the quotient $= 2$.

OF WEIGHTS AND MEASURES.

Avoirdupois Weight is the only weight made use of in mechanical calculations; and all metals, save gold and silver, are weighed by it: hence, it is not requisite here to take any other into consideration.

				Fr. Grammes.
	= 1 Dram	=		1.771
16 Drams	= 1 Ounce	=		28.346
16 Ounces	= 1 Pound	=		453.544
28 Pounds	= 1 Quarter	=		12.699 kilog.
4 Quarters	= 1 Hundred wt.	=		50.796 „
20 Hundred wt.	= 1 Ton	=		1015.920 „

NOTE.—5760 Troy grains = 1 pound Troy; and 7000 Troy grains = 1 pound Avoirdupois; hence, 175 pounds Troy = 144 pounds Avoirdupois.

Or, Avoirdupois	lbs. ×	1.21527	= Troy lbs.
Do.	ounces ×	.9115	= Do. ounces.
Troy	lbs. ×	.823	= Avoir. lbs.
Do.	ounces ×	1.1	= Do. ounces.
Do.	grains ×	.03657	= Do. drams.
Also, Avoirdupois	lbs. ×	.00893	= Cwts.
And, Do	lbs. ×	.000447	= Tons nearly.

TABLES.

Showing the relative Proportion between Foreign Weights and the Avoirdupois Pound.

1. FRENCH WEIGHTS.—DECIMAL SYSTEM.

1 Milligramme	=	.0154	Troy grains.
1 Centigramme	=	.1543	„
1 Decigramme	=	1.5434	„
1 Gramme	=	15.4340	„
1 Decagramme	=	154.3402	„
1 Hectogramme	=	1543.4023	„
1 Kilogramme	=	2.20486 lbs.	Avoirdupois.
1 Myriagramme	=	22.0486	„
1 Quintal	=	1 cwt. 3 qrs. 25 lbs.	nearly.
1 Millier or Bar	=	9 tons. 16 cwt. 3 qrs. 12 lbs.	

2. SYSTEME USUEL.

The Kilogramme =	1000	Grammes	= 2	lbs.	3	oz.	4½	Dr. Av
The Livre Usuel =	500	„	= 1	„	1	„	10¼	„
The Half ..... =	250	„	=		8	„	13¼	„
The Quarter..... =	125	„	=		4	„	6½	„
The Eighth ..... =	65.5	„	=		2	„	3¼	„
The Once ..... =	31.3	„	=		1	„	1¾	„
The Half ..... =	15.6	„	=				8⅞	„
The Quarter..... =	7.8	„	=				4½	„
The Gros ..... =	3.9	„	=				2¼	„

3. VARIOUS FOREIGN WEIGHTS IN POUNDS AVOIRDUPOIS.

Places & names of weights.	Lbs.	Places & names of weights.	Lbs.
Alexandria, rotola forfera	.9347	Genoa, peso sottile	.6938
„ rotola zaidino	1.335	„ peso grosso	.7687
„ rotola zauro	2.07	Hamburgh, pound	1.068
„ rotola mina	1.67	Havannah, pound	1.075
Amsterdam, old pound	1.09	Leghorn, pound	.764
„ new ditto	2.206	Madras, vis	3.125
Antwerp, old pound	1.033	Malabar, visay	3.001
„ new ditto	2.206	Malta, rotola	1.745
Bahia, Lisbon, and Oporto, Aragal	1.012	Mocha, rotola	1.125
Barcelona, pound	.892	Mogadore, commercial pound.	1.19
Batavia, cattie	1.36	„ market pound	1.781
Bergen, Christina, and Copenhagen, pound	1.1025	Naples, rotola	1.965
Bombay, seer	.7	Odessa and Petersburgh, pound	.9019
Bremen, pound	1.098	Port-au-Prince and Port Louis, livre poids de marc.	1.03
Buenos Ayres, Cadiz, Lima, Malaga, Valparaiso, and Vera Cruz, pound	1.015	Riga, pound	.9217
Calcutta, seer	2.053	Rio de Janeiro, aragal	1.01
Canton & Manilla, catty	1.333	Rotterdam, pound	2.204
Cape Town, pound	1.09	Smyrna, oke	2.82
Constantinople, oke	2.823	Stockholm, commercial pound	.9375
Dantzic & Memel, pound	1.033	„ iron weight	.75
		Trieste, pound	1.236
		Venice, peso grosso	1.0518
		„ peso sottile	.6643

NOTE.—America, the British West Indies, Gibraltar, and Van Dieman's Land use the pound Avoirdupois, as in England.

EXAMPLE 1.—Suppose I purchase an article in London which weighs 50 lbs. Avoirdupois, what will it weigh in Amsterdam according to their new weight?

$50 \div 2.207 = 22.606$ or 22 lbs. 9 oz. 11.137 dr. Avoirdupois.

Ex 2.—An article that weighs 60 lbs. in Leghorn, according to their weight, what will it weigh in lbs. Avoirdupois?

$.764 \times 60 = 45{,}84$ lbs. Avoirdupois nearly.

LONG MEASURE.

			Fr. Metres.
12 Inches	= 1 Foot	=	.3048
3 Feet	= 1 Yard	=	.9144
6 Feet	= 1 Fathom	=	1.8288
5½ Yards	= 1 Pole or rod	=	5.0291
40 Poles	= 1 Furlong	=	201.1632
8 Furlongs or 1760 yards	= 1 Mile	=	1609.3059
3 Miles	= 1 League	=	4827.9179

Surveying Chain = 22 yards, consists of 100 links, and each link = 7.92 inches.

FRENCH LONG MEASURE.—DECIMAL SYSTEM.

French.		English.
1 Millimetre	=	.039937 inches.
1 Centimetre	=	.39371 „
1 Decimetre	=	3.93710 „
1 Metre	=	39.37100 „
1 Decametre	=	32.80916 feet.
1 Hectometre	=	328.09167 „
1 Kilometre	=	1093.63890 yards.
1 Myriametre	=	10936.38900 „

SYSTEME USUEL.

Usuel.		Metrical.		English.
1 Ligne	= 2.31	Millimetres	=	.091 inches.
1 Pouce	= 2.77	Centimetres	=	1.090 „
1 Pied	= 3.33	Decimetres	=	13.110 „
1 Aune	= 12.	Decimetres	=	3 feet 11.24 inches.
1 Toise	= 2.	Metres	=	6 feet 6.74 inches.

THE LINEAL FOOT OF VARIOUS COUNTRIES, GIVEN IN ENGLISH INCHES.

	Inches.		Inches.
Amsterdam and Antwerp	= 11.143	Canton	= 12.65
Bahia, Lisbon, and Rio de Janeiro	= 12.944	Dantzic and Memel	= 11.3
Bergen, Copenhagen, Cape Town, Christiana, and Hamburgh	= 12.36	Port-au-Prince and Port Louis	= 12.8
		Riga	= 10.79
		Stockholm	= 11.684
		Venice	= 13.68

NOTE.—The English foot is used generally throughout America, the British West Indies, Russia, and Van Dieman's Land.

LENGTH OF A MILE IN DIFFERENT COUNTRIES, GIVEN IN ENGLISH YARDS.

	Yards.		Yards.
Dantzic	8474	Poland	8239
Denmark	8244	Portugal	6760
Flanders	6864	Prussia	8237
Germany	6859	Russia	1167
Hanover	1155	Scotland	1984
Holland	8239	Spain	4634
Hungary	9113	Sweden	1170
Ireland	2240	Switzerland	9153
Netherlands	1093	Tuscany	1808

SUPERFICIAL MEASURE.

				Fr. Sq. Metres.
144	Square inches	= 1 Sq. foot	=	.0929
9	Square feet	= 1 Sq. yard	=	.8361
30¼	Square yards	= 1 Sq. pole	=	25.2916
40	Square poles	= 1 Rood	=	1011.6662
4	Roods or 4840 Sq. yards	= 1 Acre	=	4046.6648

A Scotch Acre contains 6084 square yards.
And an Irish Acre contains 7840 square yards.

FRENCH SUPERFICIAL MEASURES.

1 Centiare	= 1.1960	Square yards.
1 Arc (a square decametre)	= 119.6046	„
1 Decare	= 1196.0460	„
1 Hectare	= 11960.4604	„

or 2 acres, 1 rood, 35 perches.

SOLID MEASURE.

				Fr. Cubic Metres.
1728	Cubic inches	= 1 Cubic foot	=	.0283
27	Cubic feet	= 1 Cubic yard	=	.7645
42	Cubic feet	= 1 Ton of Shipping	=	1.1892

A Load of unhewn timber	= 40	Cubic feet.
„ squared do	= 50	„
„ 1 inch plank	= 600	Square feet.
„ 1¼ inch do.	= 400	„
„ 2 *inch do.*	= 300	„

NUMBER OF CUBIC FEET IN A TON OF VARIOUS BODIES.

Names of Bodies.	Cubic feet in a ton.	Names of Bodies.	Cubic feet in a ton.
Marble	13.07	Beech	50.5
Granite	13.5	Teak	43
Common Stone	14.22	Span. Mahogany.	42
Paving do.	14.83	Honduras do.	64
Sand	23.5	Maple & Riga Fir	47.8
Coal	28.7	Larch	65.8
Tallow	38	Pitch Pine	53.6
English Oak	37	Oil	39
American do	41	Proof Spirits	38.6
Ash	47	Distilled Water	35.8
Elm	64.5	Sea do.	34.7

A Gallon of Oil weighs	9.32 lbs.	Avoirdupois
„ Distilled Water	10	„
„ Sea Water	10.32	„
„ Proof Spirits	9.3	„

IMPERIAL WINE MEASURE.

	1	Gill	=	8.665	cubic inches
4 Gills	= 1	Pint	=	34.659	„
2 Pints	= 1	Quart	=	69.318	„
4 Quarts	= 1	Gallon	=	277.274	„
10 Gallons	= 1	Anker	=	1.604	cubic feet.
18 Gallons	= 1	Runlet	=	2.888	„
42 Gallons	= 1	Tierce	=	6.739	„
63 Gallons	= 1	Hogshead	=	10.109	„
84 Gallons	= 1	Puncheon	=	3.478	„
126 Gallons	= 1	Pipe	=	20.218	„
252 Gallons	= 1	Tun	=	40.435	„

FRENCH MEASURES OF CAPACITY.

1 Millitre	=	.06103	cubic inches
1 Centilitre	=	.61028	„
1 Decilitre	=	6.10280	„
1 Litre (a cubic decimitre)	=	61.02803	„
1 Decalitre	=	610.28028	„
1 Hectolitre	=	3.5317	cubic feet.
1 Kilolitre	=	35.3171	„
1 Myrialitre	=	353.17146	„
The Litron usuel	=	62.45	cubic inches

A TABLE

Showing the relative value between the British Imperial Gallon and Foreign measures of capacity.

Places and names of measures.	Imp. Galls.	Places and names of measures.	Imp. Galls
Amsterdam...mingle	.266	Havannah ....arroba	3.415
„ .....kan	.220	Leghorn...wine fiasco	.499
Antwerp.....stoopen	.608	„ ...oil fiasco	.443
„ .....litre	.220	Lisbon .. ....almude	3.641
Barcelona.....cortane	2.270	Malta.....caffiso	4.582
Bordeaux.....velte	1.672	Mocha .....cuda	1.666
Cadiz....great arroba	3.540	Naples...wine barilla	9.164
„ ...small arroba	3.124	„ .....oil staja	2.226
Constantinople..alma	1.146	Oporto.....almude	5.311
Dantzic...beer anker	12.925	Petersburgh .. wedro	2.707
„ ...wine anker	9.915	Rotterdam ... ..stoop	.564
Genoa ...wine barilla	16.349	Stockholm.....kanne	.575
„ ...oil barilla	14.162	Trieste.....boccali	.312
Gibraltar .....gallon	.909	Venice....wine sechii	2.377
Hamburg.....stubjen	.797	„ .....oil miro	3.356

NOTE.—America, the British West Indies, and Van Dieman's Land, use the same measures of capacity as in England.

IMPERIAL ALE AND BEER MEASURE.

	1 Gill	=	8.665	cubic inches.
4 Gills	= 1 Pint.....	=	34.659	„
2 Pints.....	= 1 Quart	=	69.318	„
4 Quarts	= 1 Gallon	=	277.274	„
9 Gallons... ..	= 1 Firkin.....	=	1.444	cubic feet.
18 Gallons.....	= 1 Kilderkin	=	2.888	„
36 Gallons.....	= 1 Barrel	=	5.776	„
54 Gallons.....	= 1 Hogshead....	=	8.664	„
72 Gallons.....	= 1 Puncheon	=	11.553	„
108 Gallons.....	= 1 Butt.....	=	17.329	„

NOTE.—The old Ale Gallon contained 282 cubic inches, and the old Wine Gallon contained 231, hence

Imperial Gallons.....	× .98324	=	old Ale Gallons.
Imperial Gallons.....	× 1.20032	=	old Wine Gallons.
Old Ale Gallons	× 1.01704	=	Imperial Gallons.
Old Wine Gallons	× .83311	=	Imperial Gallons.
Cubic feet	× 6.232	=	Imperial Gallons.
Cubic inches	× .003607	=	Imperial Gallons.

IMPERIAL DRY MEASURE.

		1 Gill	=	8.665	cubic inches.
4 Gills	=	1 Pint	=	34.659	„
2 Pints	=	1 Quart	=	69.318	„
4 Quarts	=	1 Gallon	=	277.274	„
2 Gallons	=	1 Peck	=	554.548	„
4 Pecks	=	1 Bushel	=	1.2837	cubic feet.
8 Bushels	=	1 Quarter	=	10.2694	„
32 Bushels	=	1 Chaldron	=	41.0784	„
40 Bushels	=	1 Way	=	51.3480	„
80 Bushels	=	1 Last	=	102.6960	„

NOTE.—The Winchester bushel contained 2150.42 cubic inches, and the Imperial bushel contains 2218.192 cubic inches,—hence,

Imperial bushels.....× 1.0315157 = Winchester bushels,
and Winchester bushels....× .969447 = Imperial bushels.

A bushel of wheat is reckoned	=	60	lbs. Avoirdupois.
„ barley	=	47	„
„ oats	=	38	„
„ pease	=	64	„
„ beans	=	63	„

IMPERIAL MEASURE OF CAPACITY FOR COALS, CULM, LIME, FISH, POTATOES, FRUIT, AND OTHER GOODS.

The Gallon	=	351.9375	cubic inches.
2 Gallons	=	1 Peck	= 703.875 cubic inches.
4 Pecks	=	1 Bushel	= 2815.5
3 Bushels	=	1 Sack	= 4.888 cubic feet nearly.
12 Sacks	=	1 Chaldron	= 58.656

DIMENSIONS OF DRAWING PAPER IN FEET AND INCHES.

Wove Antiquarian	4	feet 4	inches	by 2	feet 7	inches.
Double Elephant	3	„ 4	„	by 2	„ 2	„
Atlas	2	„ 9	„	by 2	„ 2	„
Columbier	2	„ 9$\frac{3}{4}$	„	by 1	„ 11	„
Elephant	2	„ 3$\frac{3}{4}$	„	by 1	„ 10$\frac{1}{4}$	„
Imperial	2	„ 5	„	by 1	„ 9$\frac{1}{4}$	„
Super royal	2	„ 3	„	by 1	„ 7	„
Royal	2	„ 0	„	by 1	„ 7	„
Medium	1	„ 10	„	by 1	„ 6	„
Demy	1	„ 7$\frac{1}{2}$	„	by 1	„ 3$\frac{1}{2}$	„

DIMENSIONS OF IMPERIAL CONICAL LIQUID MEASURES.

Diameters.

Two Gallon...	Top	$2\frac{1}{2}$	in...	Bottom	$11\frac{1}{2}$ in...	Depth 12.66498 in.
Gallon.....	„	2	„	9	„	10.28498
Half Gallon...	„	$1\frac{3}{4}$	„	7	„	8.23415
Quart	„	$1\frac{1}{4}$	„	$5\frac{3}{4}$	„	6.33249
Pint.....	„	1	„	$4\frac{1}{2}$	„	5.14249
Half Pint.....	„	$\frac{7}{8}$	„	$3\frac{1}{2}$	„	4.11708
Gill.....	„	$\frac{5}{8}$	„	$2\frac{7}{8}$	„	3.16625

DIMENSIONS OF IMPERIAL CYLINDRICAL DRY MEASURES.

Diameters and Depths.

Eighth of a Peck.....	a cylinder of	4.45232 inches.
Forpit or Half Gallon..	„	5.60957
Gallon or Half Peck....	„	7.06762
Peck.....	„	8.90464
Half Bushel	„	11.21914
Bushel.....	„	14.13524
Quarter.....	„	28.27048

NOTE.—Multiply the decimal by 8, the product equal inches and parts of an inch.

DECIMAL FRACTIONS.

A Decimal Fraction derives its name from the Latin, *decem*, "ten," which denotes the nature of its numbers, representing the parts of an integral quantity, divided into a tenfold proportion.

NUMERATION

Teacheth to read or write any number proposed, either by words or characters.

In Decimal Fractions, the integer, or whole thing, as a gallon, a pound, a yard, &c., is supposed to be divided into ten equal parts, called tenths; those tenths into ten *equal parts, called* hundredths; and those hun-

dredths into ten equal parts, called **thousandths**; and so on, without end. So that the denominator of a decimal being always known to consist of a unit, with as many ciphers as the numerator has places, is, therefore, never expressed, being understood to be 10, 100, 1000, 10,000, &c., according as the numerator consists of 1, 2, 3, 4, or more figures; thus, instead of $\frac{2}{10}$, $\frac{24}{100}$, $\frac{211}{1000}$, the numerators only are written with a dot or comma before them, thus, .2, .24, .211.

If a unit or whole quantity of any description, as a gallon, a pound, a foot, &c., be divided into ten equal parts, the decimal represents as many of those parts as the decimal figure expresses,—thus, .7 means seven of those parts, or seven-tenths; but if the decimal consisted of two figures, unity would be understood to be divided into a hundred equal parts, of which the decimal represents as many as the figure expresses,—thus .65 means sixty-five of those parts, or sixty-five hundredths; and if the decimal consisted of three figures, unity would be supposed to be divided into a thousand equal parts, of which the decimal represents as many as the number expresses,—thus .625 is six hundred and twenty-five of those parts; or, suppose the decimal .0625, unity would be understood to be divided into 10,000 equal parts; but the value of decimal figures is made more plain by means of the following

TABLE.

Tenths	.5
Hundredths	.56
Thousandths	.567
Ten thousandths	.5678
Hundred thousandths, &c....	.56789

Thus, .5 is read five-tenths; .56 is read five-tenths and six-hundredths, or fifty-six hundredths; .567 is read five-tenths, six-hundredths, and seven-thousandths, or five hundred and sixty-seven thousandths; and so on, as in the table.

Ciphers to the right hand of decimals cause no difference in their value; for .5, .50, .500 are decimals of the same value, being each equal to $\frac{1}{2}$; that is, .5 = $\frac{5}{10}$, .50 = $\frac{50}{100}$, .500 = $\frac{500}{1000}$. But if ciphers are placed on the left hand of decimals, they diminish their value in a tenfold proportion; thus, .3, .03, .003, are three-tenths, three-hundredths, and three-thousandths, and answer to the vulgar fractions $\frac{3}{10}$, $\frac{3}{100}$, $\frac{3}{1000}$, respectively.

A whole number and decimal are thus expressed, 85.75, 85.04, &c.

REDUCTION OF DECIMALS.

By reduction we change vulgar fractions, and the lesser parts of coin, weight, measure, &c., into decimals, and find the value of any decimal given.

Because decimals increase their value towards the left hand, and decrease their value towards the right hand, in the same tenfold proportion with integers, or whole numbers, they may be annexed to whole numbers, and worked in all respects as whole numbers; hence, if simple arithmetic be well understood, there is little more to be learned than the placing of the separating point—the rule for which ought to be well attended to.

1.—*To reduce a vulgar fraction to a decimal of an equal value.*

Rule.—Add a cipher, or ciphers, to the numerator, and divide by the denominator, the quotient will be the decimal required.

EXAMPLE.—Reduce $\frac{14}{32}$ to a decimal.

32)14.0000(.4375
128
120
96
240
224
160
160

Thus you may take any number of ciphers at pleasure, but their number will be best ascertained when the work is finished; then you must have as many decimal figures as you have taken annexed ciphers in dividing; and if there are not so many in the quotient, you must prefix ciphers to the left hand of it,—thus, $\frac{1.00000}{32} = .03125$.

Sometimes the quotient figures will repeat continually, as $\frac{2}{3}$, thus, $\frac{2.000}{3} = .66\dot{6}$, then it is called a repetend, and the last figure may be dashed or marked, to distinguish it from a terminate decimal.

Sometimes two, three, or more figures will repeat, as $\frac{14}{33}$, thus, $\frac{12.0000}{33} = .3\dot{6}3\dot{6}$; such are called compound repetends or circulates, and the first and last figure may be dashed or marked.

2.—*To reduce the lesser parts of coin, weights, measures, &c., to decimals.*

RULE.—Divide the least name by such number as will reduce it to the next greater; to the decimal so obtained prefix the given number of the same name, then divide by such number as will reduce it to the next greater, always annexing ciphers to the dividend, as occasion may require: thus proceed till it be reduced to the decimal of the required integer. Or, reduce the given parts to a simple quantity, by reducing them to the lowest name mentioned; annex ciphers thereto, and divide by such numbers as will reduce them to the name required. Or, reduce the given parts to a vulgar fraction, and that fraction to a decimal.

EXAMPLE 1.—Reduce 17s. 10½d. to the decimal of a pound sterling.

$\frac{10}{2} = .5 + 10\text{d.} = \frac{10.500}{12} = .875 + 17\text{s.} = \frac{17.87500}{20} = .89375$, the decimal required.

EXAMPLE 2.—Reduce 2 feet 9 inches to the decimal of a yard.

Vulgar fraction $\frac{9}{36}$, and $\frac{33.0000}{36} = .9166$ as required.

To find the value of any given decimal.

RULE.—Multiply the decimal given by the number of parts of the next inferior denomination, cutting off the decimals from the product; then multiply the remainder by the next inferior denomination; thus proceeding till you have brought the least known parts of the integer.

EXAMPLE 1.—Required the value of .89375 of a pound sterling.

.89375
20
17.87500
12
10.50000
2
1.00000 or, 17s. 10½d.

EXAMPLE 2.—Reduce .625 of a hundred weight to its proper terms.

$.625 \times 4 = 2.500 \times 28 = 14.000$, or 2 quarters and 14 lbs.

A TABLE

Of Reciprocals, for obtaining Decimal Equivalents.

No.	Recip.	No.	Recip.	No.	Recip.	No	Recip.	No.	Recip.
1	1.000000	51	.019607	101	.009900	151	.006623	201	.004975
2	.500000	52	.019231	102	.009803	152	.006579	202	.004951
3	.333333	53	.018868	103	.009709	153	.006536	203	.004927
4	.250000	54	.018519	104	.009616	154	.006494	204	.004901
5	.200000	55	.018182	105	.009523	155	.006451	205	.004879
6	.166667	56	.017857	106	.009433	156	.006411	206	.004855
7	.142857	57	.017543	107	.009345	157	.006370	207	.004831
8	.125000	58	.017242	108	.009260	158	.006329	208	.004807
9	.111111	59	016949	109	.009174	159	.006290	209	.004785
10	.100000	60	.016667	110	.009091	160	.006250	210	.004762
11	.090901	61	.016393	111	.009010	161	.006211	211	.004740
12	.083333	62	.016129	112	.008928	162	.006172	212	.004716
13	.076923	63	.015873	113	.008850	163	.006135	213	.004695
14	.071428	64	.015625	114	.008771	164	.006097	214	.004673
15	.066667	65	.015385	115	.008695	165	.006061	215	.004651
16	.062500	66	.015151	116	.008620	166	.006025	216	.004629
17	.058823	67	.014925	117	.008548	167	.005988	217	.004609
18	.055556	68	.014705	118	.008475	168	.005952	218	.004588
19	.052632	69	.014492	119	.008403	169	.005917	219	.004566
20	.050000	70	.014285	120	.008333	170	.005882	220	.004546
21	.047620	71	.014085	121	.008264	171	.005847	221	.004525
22	.045455	72	.013889	122	.008196	172	.005813	222	.004505
23	.043078	73	.013698	123	.008130	173	.005781	223	.004485
24	.041667	74	.013513	124	.008065	174	.005748	224	.004465
25	.040000	75	.013333	125	.008000	175	.005715	225	.004444
26	.038462	76	.013158	126	.007936	176	.005682	226	.004425
27	.037038	77	.012987	127	.007875	177	.005650	227	.004406
28	.035715	78	.012820	128	.007812	178	.005618	228	.004386
29	.034483	79	.012659	129	.007752	179	.005586	229	.004366
30	.033333	80	.012500	130	.007693	180	.005556	230	.004348
31	.032259	81	.012346	131	.007634	181	.005524	231	.004329
32	.031250	82	.012195	132	.007576	182	.005495	232	.004311
33	.030303	83	.012048	133	.007519	183	.005464	233	.004292
34	.029412	84	.011904	134	.007463	184	.005434	234	.004273
35	.028572	85	.011765	135	.007408	185	.005406	235	.004256
36	.027778	86	.011628	136	.007352	186	.005376	236	.004238
37	.027028	87	.011494	137	.007299	187	.005347	237	.004220
38	.026316	88	.011364	138	.007247	188	.005320	238	.004201
39	.025642	89	.011235	139	.007195	189	.005292	239	.004184
40	.025000	90	.011111	140	.007143	190	.005264	240	.004167
41	.024390	91	.010989	141	.007093	191	.005235	241	.004150
42	.023809	92	.010870	142	.007042	192	.005208	242	.004132
43	.023255	93	.010753	143	.006994	193	.005182	243	.004116
44	.022727	94	.010639	144	.006944	194	.005155	244	.004098
45	.022222	95	.010527	145	.006896	195	.005129	245	.004081
46	.021739	96	.010417	146	.006850	196	.005102	246	.004065
47	.021276	97	.010310	147	.006802	197	.005076	247	.004048
48	.020833	98	.010204	148	.006756	198	.005051	248	.004033
49	.020408	99	.016101	149	.006712	199	.005026	249	.004016
50	.020000	100	.010000	150	.006667	200	.005800	250	.004000

The numbers in the table are the denominators of the fraction: hence, multiply the reciprocal of the denominator by the numerator of the fraction, and the product is the decimal equivalent.

Thus, suppose the decimal equivalent of 7-16ths be required :—
Reciprocal of 16 = .0625 × 7 = .4375 its decimal equivalent.

ADDITION OF DECIMALS.

RULE.—Arrange the numbers under each other, according to their several values; find the sum, as in addition of whole numbers, and cut off for decimals as many figures to the right hand as there are decimals in any one of the given numbers.

EXAMPLE.—What is the sum of 23.45, 7.849, 543.2, 8.6234, 253.004?

23.45
7.849
543.2
8.6234
253.004
836.1264

If any of the decimals be repetends, continue them beyond the others, and make them end together; then, in adding, increase the sum of the first column by as many units as there are nines therein; as,

.75 .
.6666
.8888
.875
.4444
3.6250

Here the first sum, 18, contains two nines; therefore two added to 18 = 20. The rest of the work is the same as usual in others; the repetend is 0, so the sum is finite.

If some of the decimals be repetends, and others circulates, continue them both beyond those that are finite, and till their periods end together; then to the sum of the first column add as many as would arise to carry to it if they were continued farther; so will you have a circulate in the sum. Thus,

2.5 .
3.666666
7.696969
14.372372
28.236008

. The repetend of .6, the circulate of 69 and .372, continued till their periods end together. It may easily be observed that there would be one to carry to the first column if it were carried any farther.

NOTE.—It is not always necessary to attend to the rule for repetends and circulates; three or four decimal figures, according to the rule, being sufficiently near the truth for *common calculations.*

SUBTRACTION OF DECIMALS.

RULE.—Place the numbers directly under each other according to their several values, subtract as in whole numbers, and cut off for decimals, as in addition.

EXAMPLE.—Subtract 35.87043 from 132.005.

132.005 + 10
35.87043
96.13457

If both be single repetends, make them end together; and if there be occasion to borrow at the first figure, borrow 9 only instead of 10;

thus,—.8333 + 9
.6666
.1666

If both be circulates, or one a repetend and the other a circulate, continue both till their periods end together; then if there should be occasion to borrow at the following figure, were they continued that figure farther, carry one to the first figure; and if the numbers be in different denominations, reduce them till they be alike.

Subtract $\frac{834}{999}$ from $1\frac{2}{3}$; thus,

1.666666
.834634 + 1
.831831

MULTIPLICATION OF DECIMALS.

RULE.—Place the factors under each other, and multiply them together, as in whole numbers; then point off as many figures from the product *(counting from right to left)* as there are decimal places in both factors; observing, if there be not enough, to annex as many ciphers to the left hand of the product as will supply the deficiency.

EXAMPLE.—Multiply .4375 by .125.

.4375
.125
21875
8750
4375
.0546875

Here the product of .4375 by .125 is .0546875; but as there are three places of decimals in the multiplier, and four in the multiplicand, a cipher must be added on the left hand of the product to reduce it to its proper terms.

To multiply a repetend by a single figure, add 1 to the first product for every 9 therein, so will you have a repetend in the product; and if there be several figures in the multiplier, do so with each product, and continue them till they end together; then add them as so many repetends.

If the multiplicand be a circulate, consider the increase that would arise to the first product if the multiplicand were continued farther: thus do with each product, make them end together, and add them by the rule for adding circulates.

To contract the operation so as to retain only as many decimals in the product as may be thought necessary.

RULE.—Place the unit figure of the multiplier under that figure of the multiplicand whose place is the last to be retained in the product, and dispose of the rest so that they may all stand in contrary order to that in which they are usually placed.

Then, in multiplying, reject all the figures to the right hand of the multiplying digit, and set down the product so that the right hand figures may fall in a straight line under each other; observing to increase the first figure of every line with what would arise, by carrying 1 from 5 to 14,—2 from 15 to 24,—3 from 25 to 34, &c., from the product of the two preceding figures when you begin to multiply; and the sum will be the product required.

EXAMPLE.—Multiply 27.14986 by 92.41035.

Common way.		*Contracted way.*
27.14986		27.14986
92.41035		53014.29
13	574930	24434874
81	44958	542997
2714	9860	108599
108599	44	2715
542997	2	81
24434874		14
2508.9280	650510	2508.9280

DIVISION OF DECIMALS.

[illegible] remainder is decimal or mixed [illegible] numbers, as if it were [illegible] the dividend is the number [illegible] the [illegible] number [illegible] the divisor, namely [illegible] [illegible] the divisor and [illegible] the number [illegible] the dividend.

[illegible] Decimal Places [illegible].

[illegible] we may take annexed measure, are must [illegible] the number [illegible] the [illegible] put the last [illegible] the number [illegible] the operation, annexing [illegible] ciphers will not [illegible] the value of the remainder.

[illegible]

[illegible] should be as many figures in the [illegible] as there should be decimals [illegible] figures in the [illegible] to make up the number.

[illegible] Dividend [illegible].

[illegible] [illegible] [illegible] [

A TABLE

Of the fractional parts of an inch when divided into thirty-two parts; likewise a foot of twelve inches reduced to decimals.

Parts.	Decimals.	Parts.	Decimals.	Parts of a foot.	Decimals.
$\frac{7}{8}$ & $\frac{3}{32}$	= .96875	$\frac{3}{8}$ & $\frac{3}{32}$	= .46875	11	= .9166
$\frac{7}{8}$ & $\frac{1}{16}$	= .9375	$\frac{3}{8}$ & $\frac{1}{16}$	= .4375	10	= .8333
$\frac{7}{8}$ & $\frac{1}{32}$	= .90625	$\frac{3}{8}$ & $\frac{1}{32}$	= .40625	9	= .75
$\frac{7}{8}$	= .875	$\frac{3}{8}$	= .375	8	= .6666
$\frac{3}{4}$ & $\frac{3}{32}$	= .84375	$\frac{1}{4}$ & $\frac{3}{32}$	= .34375	7	= .5833
$\frac{3}{4}$ & $\frac{1}{16}$	= .8125	$\frac{1}{4}$ & $\frac{1}{16}$	= .3125	6	= .5
$\frac{3}{4}$ & $\frac{1}{32}$	= .78125	$\frac{1}{4}$ & $\frac{1}{32}$	= .28125	5	= .4166
$\frac{3}{4}$	= .75	$\frac{1}{4}$	= .25	4	= .3333
$\frac{5}{8}$ & $\frac{3}{32}$	= .71875	$\frac{1}{8}$ & $\frac{3}{32}$	= .21875	3	= .25
$\frac{5}{8}$ & $\frac{1}{16}$	= .6875	$\frac{1}{8}$ & $\frac{1}{16}$	= .1875	2	= .1666
$\frac{5}{8}$ & $\frac{1}{32}$	= .65625	$\frac{1}{8}$ & $\frac{1}{32}$	= .15625	1	= .0833
$\frac{5}{8}$	= .625	$\frac{1}{8}$	= .125	$\frac{7}{8}$	= .07291
$\frac{1}{2}$ & $\frac{3}{32}$	= .59375	$\frac{3}{32}$	= .09375	$\frac{3}{4}$	= .0625
$\frac{1}{2}$ & $\frac{1}{16}$	= .5625	$\frac{1}{16}$	= .0625	$\frac{5}{8}$	= .0528
$\frac{1}{2}$ & $\frac{1}{32}$	= .53125	$\frac{1}{32}$	= .03125	$\frac{1}{2}$	= .04166
$\frac{1}{2}$	= .5			$\frac{3}{8}$	= .03125
				$\frac{1}{4}$	= .02083
				$\frac{1}{8}$	= .01041

The utility of this table will appear evident by means of the following example:

Suppose a board, or plate, to be $30\frac{1}{4}$ inches long, $8\frac{5}{8}$ inches broad, and $\frac{7}{8}$ and $\frac{1}{16}$ of an inch in thickness; required its content in cubic inches.

$30.25 \times 8.625 = 260.90625 \times .4375 = 114.146$, &c. cubic inches.

OF THE SQUARE ROOT.

When a number is multiplied by itself, as 6×6, or 9×9, &c., it produces the square or second power of that number; and the number itself is called the root of that square.

A root consisting of a single figure is found by inspection of the following table:—

Root	1	2	3	4	5	6	7	8	9
Squares	1	4	9	16	25	36	49	64	81
Cubes	1	8	27	64	125	216	343	512	729

To extract or find the square root of any number which consists of more figures than one.

Rule.—Make a point or dot over every second figure, commencing at the right hand, by which the given square will be pointed into periods of two figures each, except the first or left-hand period, which will sometimes have but one.

The unit figure must always be the latter figure in the period; for the decimal point must be between the periods, and not in the middle of a period.

Find the greatest root in the first period, which write in the quotient or root, and the square thereof under the same period; subtract therefrom, and to the remainder annex the next period for a dividend.

Double the quotient for a divisor; see how often the divisor is contained in the dividend, with this consideration, that the answer must be the unit's figure of the divisor.

Write the answer in the quotient, also in the unit place of the divisor; then multiply the divisor, so completed, by the last quotient figure; write the product under the dividend, and subtract therefrom; to the remainder annex the next period for a new dividend.

Thus proceed with every period; and if there be still a remainder, annex pairs of ciphers for additional periods, till you have a competent number of decimals in the root.

Vulgar fractions, &c., may be reduced to decimals.

The periods which are whole numbers give whole numbers, and decimal periods give decimals in the root.

EXAMPLE 1.—What is the square root of 76176?

```
 . . .
76176(276, or 276 × 276 = 76176.
 4
-----------------------------
47)361
   329
  ---
546)3276
   3276
  ====
```

EXAMPLE 2.—Required the root of .75.

```
  .
 .75(.866 or .866² + 44 = .75
  64
 ---
166)1100
    966
   ---
1726)10400
     10356
    -----
        44
    =====
```

EXAMPLE 3.—Required the root of .00854.

```
  . .
,00854(.029 or .029
  4          .29
 ---        ----
49)454       261
   441        58
  ---       ----
   13        841
  ===      + 13
            ----
            .00854
            ======
```

OF THE CUBE ROOT.

When a square is multiplied again by its root, as [illegible] produces the cube or third power of that root.

Single cubes are found by inspection of the preceding table.

To find the root of any number that consists of more than one figure.

Point off from the given cube into periods of three figures each, so that the last figure be the last in its period. From the first period subtract the greatest cube contained in it, and the root as a quotient, and to the remainder bring down the next period for a dividend.

Divide the dividend by three times the square of the root found, and annex what is contained in the dividend; and the quotient will be the next figure in the root.

Multiply the three last figures in the root by 30, except the last, and that product by the square of the last. Cube the last figure, and those three last found numbers together, and subtract this sum from the dividend; to the remainder bring down the next period for a new dividend, and proceed as before.

Example. Required the cube root of 444194947.

[illegible]

[illegible]	4744	[illegible]	7828840
	3		3
	56200		23648521
7 × 30 × 30 =	7560	76 × 30 × 3	20520
6 × 6 × 6 =	216	3 × 3 × 3 =	27
	63976		23848947

Involution and Evolution of numbers are very conveniently performed upon the *Engineer's Slide Rule*, for when the slide is set straight at both ends, C is a line of squares, and D a line of roots; consequently, against any number upon D is its square upon C, and against any number upon C is its root upon D.

EXAMPLE 1.—What is the square of 16?

Opposite 16 upon D is 256, the square number upon C.

EXAMPLE 2.—Required the square root of 625.

Opposite 625 upon C is 25 upon D, the root required.

The cube root is performed by inverting the slide, and setting the number to be cubed upon B to the same number upon D, and against 1 or 10 upon D is the cube number upon B. Also, set the cube number upon B to 1 or 10 upon D, and where two numbers of equal value meet upon the lines B and D is the root required.

EXAMPLE 1.—Required the cube of 9.

Set 9 upon B to 9 upon D, and against 10 upon D is 729 upon B.

EXAMPLE 2.—Required the cube root of 343.

Set 343 upon B to 10 upon D, and against 7 upon B is 7 upon D, the root required.

These lines also serve to multiply the square of any number, any number of times: thus,—

To find the product of 6 times 6, multiplied by 3.

Set 3 upon B to 6 upon D, and against 10 upon D, is 108 upon B.

A TABLE

Containing the square and cube roots of all numbers from 1 *to* 1728.

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots*
1	1.0000	1.0000	46	6.7823	3.5830
2	1.4142	1.2599	47	6.8556	3.6088
3	1.7320	1.4422	48	6.9282	3.6342
4	2.0000	1.5874	49	7.0000	3.6593
5	2.2360	1.7099	50	7.0710	3.6840
6	2.4494	1.8171	51	7.1414	3.7084
7	2.6457	1.9129	52	7.2111	3.7325
8	2.8284	2.0000	53	7.2801	3.7562
9	3.0000	2.0800	54	7.3484	3.7797
10	3.1622	2.1544	55	7.4161	3.8029
11	3.3166	2.2239	56	7.4833	3.8258
12	3.4641	2.2894	57	7.5498	3.8485
13	3.6055	2 3513	58	7.6157	3.8708
14	3.7416	2.4101	59	7.6811	3.8929
15	3.8729	2.4662	60	7.7459	3.9148
16	4.0000	2.5198	61	7.8102	3.9364
17	4.1231	2.5712	62	7.8740	3.9578
18	4.2426	2.6207	63	7.9372	3.9790
19	4.3588	2.6684	64	8.0000	4.0000
20	4.4721	2.7144	65	8.0622	4.0207
21	4.5825	2.7589	66	8.1240	4.0412
22	4.6904	2.8020	67	8.1853	4.0615
23	4.7958	2.8438	68	8.2462	4.0816
24	4.8989	2.8844	69	8.3066	4.1015
25	5.0000	2.9240	70	8.3666	4.1212
26	5.0990	2.9624	71	8.4261	4.1408
27	5.1961	3.0000	72	8.4852	4.1601
28	5.2915	3.0365	73	8.5440	4.1793
29	5.3851	3.0723	74	8.6023	4.1983
30	5.4772	3.1072	75	8.6602	4.2171
31	5.5677	3.1413	76	8.7177	4.2358
32	5.6568	3.1748	77	8.7749	4.2543
33	5.7445	3.2075	78	8.8317	4.2726
34	5.8309	3.2396	79	8.8881	4.2908
35	5.9160	3.2710	80	8.9442	4.3088
36	6.0000	3.3019	81	9.0000	4.3267
37	6.0827	3.3322	82	9.0553	4.3444
38	6.1644	3.3619	83	9.1104	4.3620
39	6.2449	3.3912	84	9.1651	4.3795
40	6.3245	3.4199	85	9.2195	4.3968
41	6.4031	3 4482	86	9.2736	4.4140
42	6.4807	3.4760	87	9.3273	4.4310
43	6.5574	3.5033	88	9.3808	4.4479
44	6.6332	3.5303	89	9.4339	4.4647
45	6.7082	3.5568	90	9.4868	4.4814

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
91	9.5393	4.4979	140	11.8321	5.1924
92	9.5916	4.5143	141	11.8743	5.2048
93	9.6436	4 5306	142	11.9163	5.2171
94	9.6953	4.5468	143	11.9582	5.2293
95	9.7467	4.5629	144	12.0000	5.2414
96	9.7979	4.5788	145	12.0415	5.2535
97	9.8488	4.5947	146	12.0830	5.2656
98	9.8994	4.6104	147	12.1243	5.2776
99	9.9498	4.6260	148	12.1655	5.2895
100	10.0000	4.6415	149	12.2065	5.3014
101	10.0498	4.6570	150	12.2474	5.3132
102	10.0995	4.6723	151	12.2882	5.3250
103	10.1488	4.6875	152	12.3288	5.3368
104	10.1980	4.7026	153	12.3693	5.3484
105	10.2469	4.7176	154	12.4096	5.3601
106	10.2956	4.7326	155	12.4498	5.3716
107	10.3440	4.7474	156	12.4899	5.3832
108	10.3923	4.7622	157	12.5299	5.3946
109	10.4403	4.7768	158	12.5698	5.4061
110	10.4880	4.7914	159	12.6095	5.4175
111	10.5356	4.8058	160	12.6491	5.4288
112	10.5830	4.8202	161	12.6885	5.4401
113	10.6301	4.8345	162	12.7279	5.4513
114	10.6770	4.8488	163	12.7671	5.4625
115	10.7238	4.8629	164	12.8062	5.4737
116	10.7703	4.8769	165	12.8452	5.4848
117	10.8166	4.8909	166	12.8840	5.4958
118	10.8627	4.9048	167	12.9228	5.5068
119	10.9087	4.9186	168	12.9614	5.5178
120	10.9544	4.9324	169	13.0000	5.5287
121	11.0000	4.9460	170	13.0384	5.5396
122	11.0453	4.9596	171	13.0766	5.5504
123	11.0905	4.9731	172	13.1148	5.5612
124	11.1355	4.9866	173	13.1529	5.5720
125	11.1803	5.0000	174	13.1909	5.5827
126	11.2249	5.0132	175	13.2287	5.5934
127	11.2694	5.0265	176	13.2664	5.6040
128	11.3137	5.0396	177	13.3041	5.6146
129	11.3578	5.0527	178	13.3416	5.6252
130	11.4017	5.0657	179	13.3790	5.6357
131	11.4455	5.0787	180	13.4164	5.6462
132	11.4891	5 0916	181	13.4536	5.6566
133	11.5325	5.1044	182	13.4907	5.6670
134	11.5758	5 1172	183	13.5277	5.6774
135	11.6189	5.1299	184	13.5646	5.6877
136	11.6619	5.1425	185	13.6014	5.6980
137	11.7046	5.1551	186	13.6381	5.7082
138	11.7473	5.1676	187	13.6747	5.7184
139	11.7898	5.1801	188	13.7113	5.7286

Numb.	*Square Roots.*	*Cube Roots*	*Numb.*	*Square Roots.*	*Cube Roots.*
189	13.7477	5.7387	238	15.4272	6.1971
190	13.7840	5.7488	239	15.4596	6.2058
191	13.8202	5.7589	240	15.4919	6.2144
192	13.8564	5.7689	241	15.5241	6.2230
193	13.8924	5.7789	242	15.5563	6.2316
194	13.9283	5.7889	243	15.5884	6.2402
195	13.9642	5.7988	244	15.6204	6.2487
196	14.0000	5.8087	245	15.6524	6.2573
197	14.0356	5.8186	246	15.6843	6.2658
198	14.0712	5.8284	247	15.7162	6.2743
199	14.1067	5.8382	248	15.7480	6.2827
200	14.1421	5.8480	249	15.7797	6.2911
201	14.1774	5.8577	250	15.8113	6.2996
202	14.2126	5.8674	251	15.8429	6.3079
203	14.2478	5.8771	252	15.8745	6.3163
204	14.2828	5.8867	253	15.9059	6.3247
205	14.3178	5.8963	254	15.9373	6.3330
206	14.3527	5.9059	255	15.9687	6.3413
207	14.3874	5.9154	256	16.0000	6.3496
208	14.4222	5.9249	257	16.0312	6.3578
209	14.4568	5.9344	258	16.0623	6.3660
210	14.4913	5.9439	259	16.0934	6.3743
211	14.5258	5.9533	260	16.1245	6.3825
212	14.5602	5.9627	261	16.1554	6.3906
213	14.5945	5.9720	262	16.1864	6.3988
214	14.6287	5.9814	263	16.2172	6.4069
215	14.6628	5 9907	264	16.2480	6.4150
216	14.6969	6.0000	265	16.2788	6.4231
217	14.7309	6.0092	266	16.3095	6.4312
218	14.7648	6.0184	267	16.3401	6.4392
219	14.7986	6.0276	268	16.3707	6.4473
220	14.8323	6.0368	269	16.4012	6.4553
221	14.8660	6.0459	270	16.4316	6.4633
222	14.8996	6.0550	271	16.4620	6.4712
223	14.9331	6.0641	272	16.4924	6.4792
224	14.9666	6.0731	273	16.5227	6.4871
225	15.0000	6.0822	274	16.5529	6.4950
226	15.0332	6.0911	275	16.5831	6.5029
227	15.0665	6.1001	276	16.6132	6.5108
228	15.0996	6.1091	277	16.6433	6.5186
229	15.1327	6.1180	278	16.6733	6.5265
230	15.1657	6.1269	279	16.7032	6.5343
231	15.1986	6.1357	280	16.7332	6.5421
232	15.2315	6.1446	281	16.7630	6.5499
233	15.2643	6.1534	282	16.7928	6.5576
234	15.2970	6.1622	283	16.8226	6.5654
235	15.3297	6.1710	284	16.8522	6.5731
236	15.3622	6.1797	285	16.8819	6.5808
237	15.3948	6.1884	286	16.9115	6.5885

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
287	16.9410	6.5962	336	18.3303	6.9520
288	16.9705	6.6038	337	18.3575	6.9589
289	17.0000	6.6114	338	18.3847	6.9658
290	17.0293	6.6191	339	18.4119	6.9726
291	17.0587	6.6267	340	18.4390	6.9795
292	17.0880	6.6342	341	18.4661	6.9863
293	17.1172	6.6418	342	18.4932	6.9931
294	17.1464	6.6493	343	18.5202	7.0000
295	17.1755	6.6569	344	18.5472	7.0067
296	17.2046	6.6644	345	18.5741	7.0135
297	17.2336	6.6719	346	18.6010	7.0203
298	17.2626	6.6794	347	18.6279	7.0271
299	17.2916	6.6868	348	18.6547	7.0338
300	17.3205	6.6943	349	18.6815	7.0405
301	17.3493	6.7017	350	18.7082	7.0472
302	17.3781	6.7091	351	18.7349	7.0540
303	17.4068	6.7165	352	18.7616	7.0606
304	17.4355	6.7239	353	18.7882	7.0673
305	17.4642	6.7313	354	18.8148	7.0740
306	17.4928	6.7386	355	18.8414	7.0806
307	17.5214	6.7459	356	18.8679	7.0873
308	17.5499	6.7533	357	18.8944	7.0939
309	17.5783	6.7606	358	18.9208	7.1005
310	17.6068	6.7678	359	18.9472	7.1071
311	17.6351	6.7751	360	18.9736	7.1137
312	17.6635	6.7824	361	19.0000	7.1203
313	17.6918	6.7896	362	19.0262	7.1269
314	17.7200	6.7968	363	19.0525	7.1334
315	17.7482	6 8040	364	19.0787	7.1400
316	17.7763	6.8112	365	19.1049	7.1465
317	17.8044	6.8184	366	19.1311	7.1530
318	17.8325	6.8256	367	19.1572	7.1595
319	17.8605	6.8327	368	19.1833	7.1660
320	17.8885	6.8399	369	19.2093	7.1725
321	17.9164	6.8470	370	19.2353	7.1790
322	17.9443	6.8541	371	19.2613	7.1855
323	17.9722	6.8612	372	19.2873	7.1919
324	18.0000	6.8682	373	19.3132	7.1984
325	18.0277	6.8753	374	19 3390	7.2048
326	18.0554	6.8823	375	19.3649	7.2112
327	18.0831	6.8894	376	19.3907	7.2176
328	18.1107	6.8964	377	19.4164	7.2240
329	18.1383	6.9034	378	19.4422	7.2304
330	18.1659	6.9104	379	19.4679	7.2367
331	18.1934	6 9173	380	19.4935	7.2431
332	18.2208	6.9243	381	19 5192	7.2495
333	18.2482	6.9313	382	19.5448	7.2558
334	18.2756	6.9383	383	19 5703	7.2621
335	18.3030	6.9451	384	19.5959	7.2684

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
385	19.6214	7.2747	434	20.8326	7.5711
386	19.6468	7.2810	435	20.8566	7.5769
387	19.6723	7.2873	436	20.8806	7.5827
388	19.6977	7.2936	437	20.9045	7.5885
389	19.7230	7.2998	438	20.9284	7.5943
390	19.7484	7.3061	439	20.9523	7.6001
391	19.7737	7.3123	440	20.9761	7.6059
392	19.7989	7.3186	441	21.0000	7.6116
393	19.8242	7.3248	442	21.0237	7.6174
394	19.8494	7.3310	443	21.0457	7.6231
395	19.8746	7.3372	444	21.0713	7.6288
396	19.8997	7.3434	445	21.0950	7.6346
397	19.9248	7.3495	446	21.1187	7.6403
398	19.9499	7.3557	447	21.1423	7.6460
399	19.9749	7.3619	448	21.1660	7.6517
400	20.0000	7.3680	449	21.1896	7.6574
401	20.0249	7.3741	450	21.2132	7.6630
402	20 0499	7.3803	451	21.2367	7.6687
403	20.0748	7.3864	452	21.2602	7.6744
404	20.0997	7.3925	453	21.2837	7.6800
405	20.1246	7.3986	454	21.3072	7.6857
406	20.1494	7.4047	455	21.3307	7.6913
407	20.1742	7.4107	456	21.3541	7.6970
408	20.1990	7.4168	457	21.3775	7.7026
409	20.2237	7.4229	458	21.4009	7.7082
410	20.2484	7.4289	459	21.4242	7.7138
411	20.2731	7.4349	460	21.4476	7.7194
412	20.2977	7.4410	461	21.4709	7.7250
413	20.3224	7.4470	462	21.4941	7.7306
414	20.3469	7.4530	463	21.5174	7.7361
415	20.3715	7.4590	464	21.5406	7.7417
416	20.3960	7.4650	465	21.5638	7.7473
417	20.4205	7.4709	466	21.5870	7.7528
418	20.4450	7.4769	467	21.6101	7.7584
419	20.4694	7.4829	468	21.6333	7.7639
420	20.4939	7.4888	469	21.6564	7.7694
421	20.5182	7.4948	470	21.6794	7.7749
422	20.5426	7.5007	471	21.7025	7.7804
423	20.5669	7.5066	472	21.7255	7.7859
424	20.5912	7.5125	473	21.7485	7.7914
425	20.6155	7.5184	474	21.7715	7.7969
426	20.6397	7.5243	475	21.7944	7.8024
427	20.6639	7.5302	476	21.8174	7.8079
428	20,6881	7.5361	477	21.8403	7.8133
429	20.7123	7.5419	478	21.8632	7.8188
430	20.7364	7.5478	479	21.8860	7.8242
431	20.7605	7.5536	480	21.9089	7.8297
432	20.7846	7.5595	481	21.9317	7.8351
433	20.8086	7.5653	482	21.9544	7.8405

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
483	21.9772	7.8460	532	23.0651	8.1028
484	22.0000	7.8514	533	23.0867	8.1079
485	22.0227	7.8568	534	23.1084	8.1129
486	22.0454	7.8622	535	23.1300	8.1180
487	22.0680	7.8676	536	23.1516	8.1230
488	22.0907	7.8729	537	23.1732	8.1281
489	22.1133	7.8783	538	23.1948	8.1331
490	22.1359	7.8837	539	23.2163	8.1382
491	22.1585	7.8890	540	23.2379	8.1432
492	22.1810	7.8944	541	23.2594	8.1482
493	22.2036	7.8997	542	23.2808	8.1532
494	22.2261	7.9051	543	23.3023	8.1583
495	22.2485	7.9104	544	23.3238	8.1633
496	22.2710	7.9157	545	23.3452	8.1683
497	22.2934	7.9210	546	23.3666	8.1733
498	22.3159	7.9264	547	23.3880	8.1782
499	22.3383	7.9317	548	23.4093	8.1832
500	22.3606	7.9370	549	23.4307	8.1882
501	22.3830	7.9422	550	23.4520	8.1932
502	22.4053	7.9475	551	23.4733	8.1981
503	22.4276	7.9528	552	23.4946	8.2031
504	22.4499	7.9581	553	23.5159	8.2080
505	22.4722	7.9633	554	23.5372	8.2130
506	22.4944	7.9686	555	23.5584	8.2179
507	22.5166	7.9738	556	23.5796	8 2228
508	22.5388	7.9791	557	23.6008	8.2278
509	22.5610	7.9843	558	23.6220	8.2327
510	22.5831	7.9895	559	23.6431	8.2376
511	22.6053	7.9947	560	23.6643	8.2425
512	22.6274	8.0000	561	23.6854	8.2474
513	22.6495	8.0052	562	23.7065	8.2523
514	22.6715	8.0104	563	23.7276	8.2572
515	22.6936	8 0155	564	23.7486	8.2621
516	22.7156	8.0207	565	23.7697	8.2670
517	22.7376	8.0259	566	23.7907	8.2719
518	22.7596	8.0311	567	23.8117	8.2767
519	22.7815	8.0362	568	23.8327	8.2816
520	22.8035	8.0414	569	23.8537	8.2864
521	22.8254	8.0466	570	23.8746	8.2913
522	22.8473	8.0517	571	23.8956	8.2961
523	22.8691	8.0568	572	23.9165	8.3010
524	22.8910	8.0620	573	23.9374	8.3058
525	22.9128	8.0671	574	23.9582	8.3106
526	22.9346	8.0722	575	23.9791	8.3155
527	22.9564	8.0773	576	24.0000	8.3203
528	22.9782	8.0824	577	24.0208	8.3251
529	23.0000	8.0875	578	24.0416	8.3299
530	23.0217	8.0926	579	24.0624	8.3347
531	23.0434	8.0977	580	24.0831	8.3395

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
581	24.1039	8.3443	630	25.0998	8.5726
582	24.1246	8.3491	631	25.1197	8.5771
583	24.1453	8.3539	632	25.1396	8.5816
584	24.1660	8.3586	633	25.1594	8.5862
585	24.1867	8.3634	634	25.1793	8.5907
586	24.2074	8.3682	635	25.1992	8.5952
587	24.2280	8.3729	636	25.2190	8.5997
588	24.2487	8.3777	637	25.2388	8.6042
589	24.2693	8.3824	638	25.2586	8.6087
590	24.2899	8.3872	639	25.2784	8.6132
591	24.3104	8.3919	640	25.2982	8.6177
592	24.3310	8.3966	641	25.3179	8.6222
593	24.3515	8.4013	642	25.3377	8.6267
594	24.3721	8.4061	643	25.3574	8.6311
595	24.3926	8.4108	644	25 3771	8.6356
596	24.4131	8.4155	645	25.3968	8.6401
597	24.4335	8 4202	646	25.4165	8.6445
598	24.4540	8.4249	647	25.4361	8.6490
599	24.4744	8.4296	648	25.4558	8.6534
600	24.4948	8.4343	649	25.4754	8 6579
601	24.5153	8 4390	650	25.4950	8.6623
602	24.5356	8.4436	651	25.5147	8.6668
603	24.5560	8.4483	652	25.5342	8.6712
604	24.5764	8.4530	653	25.5538	8.6756
605	24.5967	8.4576	654	25.5734	8.6801
606	24.6170	8.4623	655	25.5929	8.6845
607	24.6373	8.4670	656	25.6124	8.6889
608	24.6576	8.4716	657	25.6320	8.6933
609	24.6779	8.4762	658	25.6515	8 6977
610	24.6981	8.4809	659	25.6709	8.7021
611	24.7184	8.4855	660	25.6904	8.7065
612	24.7386	8.4901	661	25 7099	8.7109
613	24.7588	8.4948	662	25.7293	8.7153
614	24.7790	8.4994	663	25.7487	8.7197
615	24.7991	8.5040	664	25.7681	8.7241
616	24.8193	8.5086	665	25.7875	8.7285
617	24.8394	8.5132	666	25.8069	8.7328
618	24.8596	8.5178	667	25.8263	8.7372
619	24.8797	8.5224	668	25.8456	8.7416
620	24.8997	8.5270	669	25.8650	8.7459
621	24.9198	8.5316	670	25.8843	8.7503
622	24.9399	8.5361	671	25.9036	8.7546
623	24.9599	8.5407	672	25.9229	8.7590
624	24.9799	8.5453	673	25.9422	8.7633
625	25.0000	8.5498	674	25.9615	8.7677
626	25.0199	8.5544	675	25.9807	8.7720
627	25.0399	8.5589	676	26.0000	8.7763
628	25.0599	8.5635	677	26.0192	8.7807
629	25 0798	8.5680	678	26.0384	8.7850

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
679	26.0576	8.7893	728	26.9814	8 9958
680	26.0768	8.7936	729	27.0000	9.0000
681	26.0959	8.7979	730	27.0185	9.0041
682	26.1151	8.8022	731	27.0370	9.0082
683	26.1342	8.8065	732	27.0554	9.0123
684	26.1533	8.8108	733	27.0739	9.0164
685	26.1725	8.8151	734	27.0924	9.0205
686	26.1916	8.8194	735	27.1108	9.0246
687	26.2106	8.8237	736	27.1293	9.0287
688	26.2297	8.8280	737	27.1477	9.0328
689	26.2488	8.8322	738	27.1661	9.0368
690	26.2678	8.8365	739	27.1845	9.0409
691	26.2868	8.8408	740	27.2029	9.0450
692	26.3058	8.8450	741	27.2213	9.0491
693	26.3248	8.8493	742	27.2396	9 0531
694	26.3438	8.8535	743	27.2580	9.0572
695	26 3628	8.8578	744	27.2763	9.0613
696	26 3818	8.8620	745	27.2946	9.0653
697	26.4007	8.8663	746	27.3130	9.0694
698	26.4196	8.8705	747	27.3313	9.0734
699	26.4386	8.8748	748	27.3495	9.0775
700	26.4575	8.8790	749	27.3678	9.0815
701	26.4764	8.8832	750	27.3861	9.0856
702	26.4952	8.8874	751	27.4043	9.0896
703	26.5141	8.8917	752	27.4226	9.0936
704	26.5329	8.8959	753	27.4408	9.0977
705	26.5518	8.9001	754	27.4590	9.1017
706	26.5706	8.9043	755	27.4772	9.1057
707	26.5894	8.9085	756	27.4954	9.1097
708	26.6082	8.9127	757	27.5136	9.1137
709	26.6270	8.9169	758	27.5317	9.1177
710	26.6458	8.9211	759	27.5499	9.1218
711	26.6645	8 9253	760	27.5680	9.1258
712	26.6833	8.9294	761	27.5862	9.1298
713	26 7020	8 9336	762	27.6043	9.1338
714	26 7207	8.9378	763	27.6224	9.1377
715	26.7394	8.9420	764	27.6405	9.1417
716	26.7581	8.9461	765	27.6586	9.1457
717	26.7768	8.9503	766	27.6767	9.1497
718	26.7955	8.9545	767	27.6947	9.1537
719	26.8141	8 9586	768	27.7128	9.1577
720	26.8328	8.9628	769	27.7308	9.1616
721	26.8514	8.9669	770	27.7488	9.1656
722	26.8700	8.9711	771	27.7668	9.1696
723	26.8886	8 9752	772	27.7848	9.1735
724	26.9072	8.9793	773	27.8028	9.1775
725	26.9258	8.9835	774	27.8208	9.1815
726	26.9443	8.9876	775	27.8388	9.1854
727	26.9629	8.9917	776	27.8567	9.1894

Numb.	Square Roots.	Cube Roots	Numb.	Square Roots.	Cube Roots.
777	27.8747	9.1933	826	28.7402	9.3826
778	27.8926	9.1972	827	28.7576	9.3864
779	27.9105	9.2012	828	28.7749	9.3902
780	27.9284	9 2051	829	28.7923	9.3940
781	27.9463	9.2090	830	28.8097	9.3977
782	27.9642	9.2130	831	28.8270	9.4015
783	27.9821	9.2169	832	28.8444	9.4053
784	28.0000	9.2208	833	28.8617	9.4091
785	28.0178	9.2247	834	28 8790	9.4128
786	28.0356	9.2287	835	28.8963	9.4166
787	28.0535	9.2326	836	28 9136	9.4203
788	28.0713	9.2365	837	28.9309	9.4241
789	28.0891	9.2404	838	28 9482	9.4278
790	28.1069	9.2443	839	28.9654	9.4316
791	28.1247	9.2482	840	28.9827	9.4353
792	28.1424	9.2521	841	29.0000	9.4391
793	28.1602	9.2560	842	29.0172	9.4428
794	28.1780	9.2599	843	29.0344	9.4466
795	28.1957	9.2637	844	29.0516	9.4503
796	28.2134	9.2676	845	29.0688	9.4540
797	28.2311	9.2715	846	29.0860	9.4577
798	28.2488	9.2754	847	29.1032	9.4615
799	28.2665	9.2793	848	29.1204	9.4652
800	28.2842	9.2831	849	29.1376	9.4689
801	28.3019	9.2870	850	29.1547	9.4726
802	28.3196	9 2909	851	29.1719	9.4761
803	28.3372	9.2947	852	29.1890	9.4801
804	28.3548	9.2986	853	29 2061	9.4838
805	28.3725	9.3024	854	29.2232	9.4875
806	28.3901	9.3063	855	29.2403	9.4912
807	28.4077	9.3101	856	29.2574	9.4949
808	28.4253	9.3140	857	29.2745	9.4986
809	28.4429	9.3178	858	29.2916	9.5023
810	28.4604	9.3216	859	29.3087	9.5059
811	28.4780	9.3255	860	29·3257	9.5096
812	28.4956	9.3293	861	29.3428	9.5133
813	28.5131	9.3331	862	29.3598	9.5170
814	28.5306	9 3370	863	29.3768	9.5207
815	28.5482	9.3408	864	29.3938	9.5244
816	28.5657	9.3446	865	29.4108	9.5280
817	28.5832	9.3484	866	29.4278	9.5317
818	28.6006	9.3522	867	29.4448	9.5354
819	28.6181	9.3560	868	29.4618	9.5390
820	28.6356	9.3599	869	29.4788	9.5427
821	28.6530	9.3637	870	29.4957	9.5464
822	28.6705	9.3675	871	29.5127	9.5500
823	28.6379	9.3713	872	29.5296	9.5537
824	28 7054	9.3750	873	29.5465	9.5573
825	28.7228	9.3788	874	29.5634	9.5610

Numb	*Square Roots.*	*Cube Roots*	*Numb.*	*Square Roots*	*Cube Roots.*
875	29.5803	9.5646	924	30 3973	9.7399
876	29.5972	9.5682	925	30.4138	9.7434
877	29.6141	9.5719	926	30.4302	9.7469
878	29.6310	9.5755	927	30.4466	9.7504
879	29.6479	9 5792	928	30.4630	9.7539
880	29.6647	9.5828	929	30.4795	9.7575
881	29.6816	9.5864	930	30.4959	9.7610
882	29.6984	9.5900	931	30.5122	9.7644
883	29.7153	9.5937	932	30.5286	9.7679
884	29.7321	9.5973	933	30 5450	9.7714
885	29.7489	9.6009	934	30.5614	9.7749
886	29.7657	9.6045	935	30.5777	9.7784
887	29.7825	9.6081	936	30.5941	9.7829
888	29.7993	9 6117	937	30.6104	9.7854
889	29.8161	9 6153	938	30.6267	9.7889
890	29.8328	9.6190	939	30.6431	9.7923
891	29.8496	9.6226	940	30.6594	9.7958
892	29.8663	9.6262	941	30.6757	9.7993
893	29.8831	9.6297	942	30.6920	9.8028
894	29.8998	9.6333	943	30.7083	9.8062
895	29.9165	9.6369	944	30.7245	9.8097
896	29.9332	9.6405	945	30.7408	9.8131
897	29.9499	9 6441	946	30.7571	9 8166
898	29.9666	9.6477	947	30.7733	9.8201
899	29.9833	9.6513	948	30.7896	9.8235
900	30.0000	9.6548	949	30.8058	9.8270
901	30.0166	9.6584	950	30.8220	9.8304
902	30 0333	9.6620	951	30.8382	9.8339
903	30.0499	9.6656	952	30.8544	9.8373
904	30.0665	9.6691	953	30.8706	9.8408
905	30 0832	9.6727	954	30.8868	9.8442
906	30 0998	9.6763	955	30.9030	9.8476
907	30.1164	9.6798	956	30.9192	9.8511
908	30.1330	9.6834	957	30.9354	9.8545
909	30.1496	9.6869	958	30.9515	9.8579
910	30.1662	9.6905	959	30.9677	9.8614
911	30.1827	9.6940	960	30.9838	9.8648
912	30.1993	9.6976	961	31.0000	9.8682
913	30.2158	9.7011	962	31.0161	9.8716
914	30.2324	9.7046	963	31.0322	9.8751
915	30 2489	9.7082	964	31.0483	9.8785
916	30.2654	9 7117	965	31.0644	9.8819
917	30.2820	9.7153	966	31.0805	9.8853
918	30.2985	9.7188	967	31 0966	9.8887
919	30.3150	9.7223	968	31.1126	9.8921
920	30.3315	9.7258	969	31.1287	9 8955
921	30.3479	9.7294	970	31.1448	9.8989
922	30.3644	9 7329	971	31.1608	9 9023
923	30.3809	9.7364	972	31.1769	9.9057

Numb.	Square Roots.	Cube Roots	Numb.	Square Roots.	Cube Roots.
973	31.1929	9.9091	1022	31.9687	10 0728
974	31.2089	9.9125	1023	31.9843	10 0760
975	31.2249	9.9159	1024	32.0000	10.0793
976	31.2409	9.9193	1025	32.0156	10 0826
977	31.2569	9.9227	1026	32.0312	10.0859
978	31.2729	9.9261	1027	32.0468	10.0892
979	31 2889	9.9295	1028	32.0624	10.0924
980	31.3049	9.9328	1029	32.0780	10.0957
981	31.3209	9.9362	1030	32 0936	10.0990
982	31.3368	9.9396	1031	32.1091	10.1022
983	31.3528	9.9430	1032	32.1247	10.1055
984	31.3687	9.9463	1033	32.1403	10.1088
985	31.3847	9.9497	1034	32 1558	10.1120
986	31.4006	9 9531	1035	32.1714	10 1153
987	31.4165	9 9564	1036	32 1869	10.1185
988	31.4324	9.9598	1037	32.2024	10.1218
989	31.4483	9.9631	1038	32.2180	10.1250
990	31.4642	9 9665	1039	32.2335	10.1283
991	31.4801	9 9699	1040	32.2490	10.1315
992	31.4960	9 9732	1041	32.2645	10.1348
993	31.5119	9.9766	1042	32 2800	10.1380
994	31.5277	9 9799	1043	32.2955	10.1413
995	31.5436	9.9833	1044	32 3109	10.1445
996	31.5594	9.9866	1045	32.3264	10.1478
997	31.5753	9.9899	1046	32.3419	10.1510
998	31 5911	9.9933	1047	32.3573	10 1542
999	31.6069	9 9966	1048	32.3728	10.1575
1000	31.6227	10.0000	1049	32 3882	10.1607
1001	31.6385	10.0033	1050	32.4037	10.1639
1002	31.6543	10.0066	1051	32.4191	10.1671
1003	31.6701	10.0099	1052	32.4345	10.1704
1004	31.6859	10 0133	1053	32.4499	10.1736
1005	31.7017	10.0166	1054	32.4653	10.1768
1006	31.7175	10.0199	1055	32.4807	10.1800
1007	31.7332	10.0232	1056	32 4961	10.1832
1008	31.7490	10.0265	1057	32.5115	10.1865
1009	31.7647	10 0299	1058	32.5269	10 1897
1010	31.7804	10.0332	1059	32.5422	10.1929
1011	31.7962	10.0365	1060	32.5576	10.1961
1012	31.8119	10.0398	1061	32.5729	10.1993
1013	31.8276	10.0431	1062	32 5883	10.2025
1014	31.8433	10.0464	1063	32.6036	10.2057
1015	31.8590	10.0497	1064	32.6190	10 2089
1016	31.8747	10 0530	1065	32.6343	10.2121
1017	31.8904	10.0563	1066	32.6496	10 2153
1018	31.9061	10 0596	1067	32 6649	10.2185
1019	31.9217	10.0629	1068	32.6802	10.2217
1020	31.9374	10.0662	1069	32.6955	10.2249
1021	31.9530	10.0695	1070	32.7108	10.2280

Numb.	Square Roots.	Cube Roots	Numb.	Square Roots	Cube Roots.
1071	32.7261	10.2312	1120	33.4664	10.3849
1072	32.7414	10.2344	1121	33.4813	10.3880
1073	32.7566	10.2376	1122	33 4962	10.3911
1074	32.7719	10.2408	1123	33.5111	10.3942
1075	32.7871	10.2439	1124	33.5261	10.3973
1076	32.8024	10.2471	1125	33.5410	10 4004
1077	32.8176	10.2503	1126	33.5559	10.4034
1078	32.8329	10.2535	1127	33.5708	10.4065
1079	32.8481	10.2566	1128	33.5857	10.4096
1080	32.8633	10.2598	1129	33.6005	10.4127
1081	32.8785	10.2630	1130	33.6154	10.4158
1082	32.8937	10.2661	1131	33.6303	10.4188
1083	32.9089	10.2693	1132	33.6452	10.4219
1084	32.9241	10.2725	1133	33.6600	10.4250
1085	32 9393	10.2756	1134	33.6749	10.4280
1086	32 9545	10.2788	1135	33.6897	10.4311
1087	32.9696	10.2819	1136	33 7045	10.4342
1088	32.9848	10.2851	1137	33.7194	10.4372
1089	33.0000	10.2882	1138	33.7342	10.4403
1090	33.0151	10.2914	1139	33.7490	10.4433
1091	33.0302	10.2945	1140	33.7638	10.4464
1092	33 0454	10.2977	1141	33.7786	10.4494
1093	33 0605	10.3008	1142	33 7934	10.4525
1094	33.0756	10.3039	1143	33.8082	10.4555
1095	33.0907	10.3071	1144	33.8230	10.4586
1096	33.1058	10.3102	1145	33.8378	10.4616
1097	33.1209	10.3134	1146	33.8526	10.4647
1098	33.1360	10.3165	1147	33.8673	10.4677
1099	33.1511	10.3196	1148	33.8821	10.4708
1100	33.1662	10.3228	1149	33.8969	10.4738
1101	33.1813	10.3259	1150	33.9116	10.4768
1102	33.1963	10.3290	1151	33.9263	10.4799
1103	33.2114	10.3321	1152	33.9411	10.4829
1104	33.2264	10.3352	1153	33.9558	10.4859
1105	33.2415	10.3384	1154	33.9705	10.4890
1106	33.2565	10.3415	1155	33.9852	10.4920
1107	33.2716	10.3446	1156	34.0000	10 4950
1108	33.2866	10.3477	1157	34.0147	10.4981
1109	33.3016	10.3508	1158	34.0293	10.5011
1110	33.3166	10.3539	1159	34.0440	10.5041
1111	33.3316	10.3570	1160	34.0587	10.5071
1112	33.3466	10.3602	1161	34.0734	10.5101
1113	33.3616	10 3633	1162	34.0881	10.5132
1114	33.3766	10.3664	1163	34.1027	10.5162
1115	33.3916	10.3695	1164	34.1174	10.5192
1116	33.4065	10.3726	1165	34.1320	10.5222
1117	33.4215	10.3757	1166	34.1467	10.5252
1118	33.4365	10.3788	1167	34.1613	10 5282
1119	33.4514	10.3818	1168	34.1760	10.5312

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1169	34.1906	10.5342	1218	34.8998	10.6794
1170	34.2052	10 5372	1219	34.9141	10.6823
1171	34.2198	10.5402	1220	34.9284	10 6852
1172	34.2344	10.5432	1221	34 9428	10.6882
1173	34.2490	10.5462	1222	34.9571	10.6911
1174	34.2636	10 5492	1223	34.9714	10 6940
1175	34.2782	10.5522	1224	34.9857	10 6969
1176	34.2928	10.5552	1225	35.0000	10.6998
1177	34.3074	10.5582	1226	35 0142	10 7027
1178	34.3220	10.5612	1227	35.0285	10 7056
1179	34.3365	10.5642	1228	35.0428	10.7086
1180	34.3511	10.5672	1229	35 0570	10.7115
1181	34.3656	10.5702	1230	35.0713	10 7144
1182	34.3802	10.5731	1231	35.0856	10 7173
1183	34 3947	10.5761	1232	35.0998	10.7202
1184	34.4093	10 5791	1233	35.1140	10.7231
1185	34.4238	10.5821	1234	35.1283	10 7260
1186	34 4383	10.5850	1235	35.1425	10.7289
1187	34.4528	10.5880	1236	35.1567	10.7318
1188	34.4673	10 5910	1237	35.1710	10.7346
1189	34.4818	10.5940	1238	35.1852	10.7375
1190	34.4963	10.5969	1239	35.1994	10 7404
1191	34.5108	10.5999	1240	35.2136	10.7433
1192	34.5253	10.6029	1241	35.2278	10.7462
1193	34.5398	10.6058	1242	35.2420	10.7491
1194	34.5543	10.6088	1243	35.2562	10.7520
1195	34.5687	10.6118	1244	35.2703	10.7549
1196	34.5832	10 6147	1245	35.2845	10.7577
1197	34.5976	10 6177	1246	35.2987	10.7606
1198	34.6121	10.6206	1247	35 3128	10 7635
1199	34.6265	10.6236	1248	35.3270	10.7664
1200	34.6410	10.6265	1249	35.3411	10.7693
1201	34.6554	10.6295	1250	35 3553	10.7721
1202	34.6698	10.6324	1251	35.3694	10.7750
1203	34.6842	10.6354	1252	35.3836	10.7779
1204	34.6987	10.6383	1253	35.3977	10.7807
1205	34.7131	10.6413	1254	35 4118	10.7836
1206	34.7275	10.6442	1255	35.4259	10.7865
1207	34 7419	10.6472	1256	35 4400	10.7893
1208	34.7562	10.6501	1257	35.4541	10.7922
1209	34.7706	10.6530	1258	35.4682	10.7951
1210	34 7850	10 6560	1259	35.4823	10.7979
1211	34.7994	10.6589	1260	35.4964	10.8008
1212	34.8137	10.6618	1261	35.5105	10.8036
1213	34.8281	10.6648	1262	35.5246	10.8065
1214	34.8425	10.6677	1263	35.5387	10.8093
1215	34.8568	10.6706	1264	35.5527	10.8122
1216	34.8711	10.6736	1265	35.5668	10.8150
1217	34.8855	10.6765	1266	35.5808	10 8179

Numb.	Square Roots.	Cube Roots	Numb.	Square Roots.	Cube Roots.
1267	35.5949	10.8207	1316	36.2767	10.9585
1268	35.6089	10.8236	1317	36.2904	10.9612
1269	35.6230	10.8264	1318	36.3042	10.9640
1270	35.6370	10.8293	1319	36.3180	10.9668
1271	35.6510	10.8321	1320	36.3318	10.9696
1272	35.6651	10 8350	1321	36.3455	10.9723
1273	35.6791	10 8378	1322	36.3593	10.9751
1274	35.6931	10,8406	1323	36.3730	10.9779
1275	35.7071	10.8435	1324	36.3868	10.9806
1276	35.7211	10 8463	1325	36.4005	10.9834
1277	35.7351	10.8491	1326	36.4142	10.9862
1278	35.7491	10.8520	1327	36.4280	10.9889
1279	35.7631	10.8548	1328	36.4417	10.9917
1280	35.7770	10.8576	1329	36.4554	10.9944
1281	35.7910	10.8604	1330	36.4691	10.9972
1282	35.8050	10.8633	1331	36 4828	11.0000
1283	35.8189	10 8661	1332	36.4965	11.0027
1284	35.8329	10.8689	1333	36.5102	11.0055
1285	35.8468	10.8717	1334	36 5239	11.0082
1286	35.8608	10.8746	1335	36 5376	11.0110
1287	35.8747	10.8774	1336	36.5513	11.0137
1288	35.8887	10 8802	1337	36.5650	11.0165
1289	35.9026	10.8830	1338	36.5786	11.0192
1290	35.9165	10.8858	1339	36 5923	11.0219
1291	35.9304	10.8886	1340	36.6060	11.0247
1292	35.9444	10.8914	1341	36.6196	11.0274
1293	35.9583	10.8943	1342	36.6333	11.0302
1294	35.9722	10.8971	1343	36.6469	11.0329
1295	35.9861	10 8999	1344	36.6606	11.0356
1296	36.0000	10 9027	1345	36.6742	11.0384
1297	36.0138	10.9055	1346	36.6878	11.0411
1298	36.0277	10.9083	1347	36 7014	11.0439
1299	36.0416	10.9111	1348	36 7151	11.0466
1300	36.0555	10.9139	1349	36.7287	11.0493
1301	36.0693	10.9167	1350	36.7423	11.0520
1302	36 0832	10.9195	1351	36.7559	11.0548
1303	36.0970	10.9223	1352	36.7695	11 0575
1304	36.1109	10.9251	1353	36.7831	11.0602
1305	36.1247	10.9279	1354	36.7967	11.0629
1306	36.1386	10.9306	1355	36.8103	11.0657
1307	36.1524	10.9334	1356	36.8239	11.0684
1308	36.1662	10.9362	1357	36.8374	11.0711
1309	36.1801	10.9390	1358	36.8510	11.0738
1310	36.1939	10.9418	1359	36.8646	11.0766
1311	36.2077	10.9446	1360	36.8781	11.0793
1312	36.2215	10.9474	1361	36.8917	11.0820
1313	36.2353	10.9501	1362	36 9052	11.0847
1314	36.2491	10.9529	1363	36.9188	11 0874
1315	36.2629	10.9557	1364	36.9323	11.0901

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1365	36.9459	11.0928	1414	37.6031	11.2240
1366	36.9594	11.0955	1415	37.6164	11.2267
1367	36.9729	11.0982	1416	37.6297	11.2293
1368	36.9864	11.1009	1417	37.6430	11.2319
1369	37.0000	11.1037	1418	37.6563	11.2346
1370	37.0135	11.1064	1419	37.6696	11.2372
1371	37.0270	11.1091	1420	37.6828	11.2399
1372	37.0405	11.1118	1421	37.6961	11.2425
1373	37.0540	11.1145	1422	37.7094	11.2451
1374	37.0675	11.1172	1423	37.7226	11.2478
1375	37.0809	11.1199	1424	37.7359	11.2504
1376	37.0944	11.1225	1425	37.7491	11.2530
1377	37.1079	11.1252	1426	37.7624	11.2557
1378	37.1214	11.1279	1427	37.7756	11.2583
1379	37.1348	11.1306	1428	37.7888	11.2609
1380	37.1483	11.1333	1429	37.8021	11.2636
1381	37.1618	11.1360	1430	37.8153	11.2662
1382	37.1752	11.1387	1431	37.8285	11.2688
1383	37.1887	11.1414	1432	37.8417	11.2714
1384	37 2021	11.1441	1433	37.8549	11.2741
1385	37.2155	11.1467	1434	37.8681	11.2767
1386	37.2290	11.1494	1435	37.8813	11.2793
1387	37.2424	11.1521	1436	37.8945	11.2819
1388	37.2558	11.1548	1437	37.9077	11.2845
1389	37.2692	11.1575	1438	37.9209	11.2872
1390	37.2827	11.1601	1439	37.9341	11.2898
1391	37.2961	11.1628	1440	37.9473	11.2924
1392	37.3095	11.1655	1441	37.9605	11.2950
1393	37.3229	11.1682	1442	37.9736	11.2976
1394	37.3363	11.1708	1443	37.9868	11.3002
1395	37 3496	11.1735	1444	38.0000	11.3028
1396	37.3630	11.1762	1445	38.0131	11.3054
1397	37.3764	11.1788	1446	38.0263	11.3080
1398	37.3898	11.1815	1447	38.0394	11.3107
1399	37.4032	11.1842	1448	38.0525	11.3133
1400	37.4165	11.1868	1449	38.0657	11.3159
1401	37.4299	11.1895	1450	38.0788	11.3185
1402	37.4432	11.1922	1451	38.0919	11.3211
1403	37.4566	11.1948	1452	38.1051	11.3237
1404	37.4699	11.1975	1453	38.1182	11.3263
1405	37.4833	11.2001	1454	38.1313	11.3289
1406	37.4966	11.2028	1455	38.1444	11.3315
1407	37.5099	11.2055	1456	38.1575	11.3341
1408	37.5233	11.2081	1457	38.1706	11.3366
1409	37.5366	11.2108	1458	38.1837	11.3392
1410	37.5499	11.2134	1459	38.1968	11.3418
1411	37.5632	11.2161	1460	38.2099	11.3444
1412	37.5765	11.2187	1461	38.2230	11.3470
1413	37.5898	11.2214	1462	38.2361	11.3496

Numb.	Square Roots.	Cube Roots	Numb.	Square Roots.	Cube Roots.
1267	35.5949	10.8207	1316	36.2767	10.9535
1268	35.6089	10.8236	1317	36.2904	10.9612
1269	35.6230	10.8264	1318	36.3042	10.9640
1270	35.6370	10.8293	1319	36.3180	10.9668
1271	35.6510	10.8321	1320	36.3318	10.9696
1272	35.6651	10 8350	1321	36.3455	10.9723
1273	35.6791	10 8378	1322	36.3593	10.9751
1274	35.6931	10.8406	1323	36.3730	10.9779
1275	35.7071	10.8435	1324	36.3868	10.9806
1276	35.7211	10.8463	1325	36.4005	10.9834
1277	35.7351	10.8491	1326	36.4142	10.9862
1278	35.7491	10.8520	1327	36.4280	10.9889
1279	35.7631	10.8548	1328	36.4417	10.9917
1280	35.7770	10.8576	1329	36.4554	10.9944
1281	35.7910	10.8604	1330	36.4691	10.9972
1282	35.8050	10.8633	1331	36 4828	11.0000
1283	35.8189	10 8661	1332	36.4965	11.0027
1284	35.8329	10.8689	1333	36.5102	11.0055
1285	35.8468	10.8717	1334	36 5239	11.0082
1286	35.8608	10.8746	1335	36 5376	11.0110
1287	35.8747	10.8774	1336	36.5513	11.0137
1288	35.8887	10 8802	1337	36.5650	11.0165
1289	35.9026	10.8830	1338	36.5786	11.0192
1290	35.9165	10.8858	1339	36 5923	11.0219
1291	35.9304	10.8886	1340	36.6060	11.0247
1292	35.9444	10.8914	1341	36.6196	11.0274
1293	35.9583	10.8943	1342	36.6333	11.0302
1294	35.9722	10.8971	1343	36.6469	11.0329
1295	35.9861	10.8999	1344	36.6606	11.0356
1296	36.0000	10 9027	1345	36.6742	11.0384
1297	36.0138	10.9055	1346	36.6878	11.0411
1298	36.0277	10.9083	1347	36 7014	11.0439
1299	36.0416	10 9111	1348	36 7151	11.0466
1300	36.0555	10.9139	1349	36 7287	11.0493
1301	36.0693	10.9167	1350	36.7423	11.0520
1302	36 0832	10.9195	1351	36.7559	11.0548
1303	36.0970	10.9223	1352	36.7695	11 0575
1304	36.1109	10.9251	1353	36.7831	11.0602
1305	36.1247	10.9279	1354	36.7967	11.0629
1306	36.1386	10.9306	1355	36.8103	11.0657
1307	36.1524	10.9334	1356	36.8239	11.0684
1308	36.1662	10.9362	1357	36.8374	11.0711
1309	36.1801	10.9390	1358	36.8510	11.0738
1310	36.1939	10.9418	1359	36.8646	11.0766
1311	36.2077	10.9446	1360	36.8781	11.0793
1312	36.2215	10.9474	1361	36.8917	11.0820
1313	36.2353	10.9501	1362	36 9052	11.0847
1314	36.2491	10.9529	1363	36.9188	11 0874
1315	36.2629	10.9557	1364	36.9323	11.0901

...ARE AND CUBE ROOTS OF NUMBERS.

...	...	...	Numb.	Square Roots.	Cube Roots.
			1610	40.1248	11.7293
			1611	40.1372	11.7328
			1612	40.1497	11.7352
			1613	40.1621	11.7377
			1614	40.1746	11.7390
			1615	40.1870	11.7425
			1616	40.1995	11.7449
			1617	40.2119	11.7473
			1618	40.2243	11.7497
			1619	40.2367	11.7521
			1620	40.2492	11.7446
			1621	40.2616	11.7470
			1622	40.2740	11.7494
			1623	40.2864	11.7518
			1624	40.2988	11.7542
			1625	40.3112	11.7566
			1626	40.3236	11.7590
			1627	40.3360	11.7614
			1628	40.3484	11.7639
			1629	40.3608	11.7663
			1630	40.3732	11.7687
			1631	40.3856	11.7711
			1632	40.3980	11.7735
			1633	40.4103	11.7759
			1634	40.4227	11.7783
			1635	40.4351	11.7807
			1636	40.4475	11.7831
			1637	40.4598	11.7855
			1638	40.4722	11.7879
			1639	40.4846	11.7903
			1640	40.4969	11.7927
			1641	40.5092	11.7951
			1642	40.5216	11.7975
			1643	40.5339	11.7999
			1644	40.5462	11.8023
			1645	40.5586	11.8047
			1646	40.5709	11.8071
			1647	40.5832	11.8094
			1648	40.5955	11.8118
			1649	40.6078	11.8142
			1650	40.6201	11.8166
			1651	40.6324	11.8190
			1652	40.6447	11.8214
			1653	40.6570	11.8238
			1654	40.6693	11.8261
			1655	40.6816	11.8285
			1656	40.6938	11.8309
			1657	40.7062	11.8333
			1658	40.7185	11.8357

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1659	40.7308	11.8381	1694	41.1582	11.9207
1660	40 7430	11.8404	1695	41.1703	11.9231
1661	40.7553	11.8428	1696	41.1825	11.9254
1662	40.7676	11.8452	1697	41.1946	11.9278
1663	40.7798	11.8476	1698	41.2067	11.9301
1664	40.7921	11.8499	1699	41.2189	11.9324
1665	40.8044	11.8523	1700	41.2310	11.9348
1666	40.8166	11.8547	1701	41.2431	11.9371
1667	40.8289	11.8571	1702	41.2553	11.9395
1668	40.8411	11.8594	1703	41.2674	11.9418
1669	40.8533	11.8618	1704	41.2795	11.9441
1670	40.8656	11.8642	1705	41.2916	11.9465
1671	40.8778	11.8665	1706	41.3037	11.9488
1672	40.8900	11.8689	1707	41.3158	11.9511
1673	40.9023	11.8713	1708	41.3279	11.9535
1674	40.9145	11.8736	1709	41.3400	11.9558
1675	40.9267	11.8760	1710	41.3521	11.9581
1676	40.9389	11.8784	1711	41.3642	11.9605
1677	40.9511	11.8807	1712	41.3763	11.9628
1678	40.9633	11.8831	1713	41.3884	11.9651
1679	40.9756	11.8854	1714	41.4004	11.9675
1680	40.9878	11.8878	1715	41.4125	11.9698
1681	41.0000	11.8902	1716	41.4246	11.9721
1682	41.0121	11.8925	1717	41.4366	11.9744
1683	41.0243	11.8949	1718	41.4487	11.9768
1684	41.0365	11.8972	1719	41.4608	11 9791
1685	41.0487	11.8996	1720	41.4728	11.9814
1686	41.0609	11.9019	1721	41.4849	11.9837
1687	41.0731	11.9043	1722	41.4969	11.9860
1688	41.0852	11.9066	1723	41.5090	11.9884
1689	41.0974	11.9090	1724	41.5210	11.9907
1690	41.1096	11.9113	1725	41.5331	11.9930
1691	41.1217	11.9137	1726	41.5451	11.9953
1692	41.1339	11.9160	1727	41.5571	11.9976
1693	41.1460	11.9184	1728	41.5692	12.0000

To find the root of a number, consisting of integers and decimals.

RULE.—Multiply the difference between the root of the integer part of the given number, and the root of the next higher integer number, by the decimal part of the given number, and add the product to the root of the integer number given; the sum will be the root of the number required, correct in all cases of the square root to 3 places of decimals, and in the cube root to 7.

EXAMPLE 1.—Required the square root of 60.2.

$\sqrt{61} = 7.8102$
$\sqrt{60} = 7.7459$

difference .0643
× .2

= .01286
+ 7.7459

$\sqrt{60.2} = 7.75876$ as required, correct to 3 places of decimals.

EXAMPLE 2.—Required the cube root of 843.75.

$\sqrt[3]{844} = 9.4503$
$\sqrt[3]{843} = 9.4466$

difference .0037
× .75

= .002775
+ 9.4466

$\sqrt[3]{843.75} = 9.449375$ as required.

If the square root is required correct to more places of decimals, the following rule is correct to 7 places:

Multiply the root of the nearest integer number by twice the difference between that and the given number, and divide the product by 3 times the integer number added to the given number; and the quotient added to the root of the integer number will be the root of the given number nearly. Then, the root of 60.2 will stand thus,

$\sqrt{60}$ 7.7459
× .4 2 × 2

$60 \times 3 = 180 + 60.2 = 240.2)3.09836(.01289 + 7.7459 = 7.75889$ the root required.
2402

6963
4804

21596
19216

23800

If the number consist wholly of decimals, the root will be decimals also.

PRACTICAL GEOMETRY.

Practical Geometry is the art of describing mathematical figures by a ruler and compasses, or other instruments proper for the purpose.

PROBLEM I.

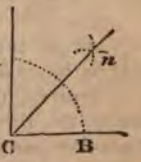
To divide a given line into two equal parts.

From A and B as centres, with any distance greater than half the length of the line, describe arcs cutting each other in *m* and *n*; then a line drawn through the points *m* and *n* will divide the line into two equal parts, as required.

PROBLEM II.

To divide a given angle into two equal parts.

From the point C as a centre, with any distance at pleasure, describe the arc A B; and from A and B as centres, with the same or any other convenient distance, describe arcs cutting each other in *n*; then a line drawn from the point C, through *n*, will divide the angle as required.



Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1561	39.5094	11.6002	1610	40.1248	11.7203
1562	39.5221	11.6027	1611	40.1372	11.7228
1563	39.5347	11.6052	1612	40.1497	11.7252
1564	39.5474	11.6076	1613	40.1621	11.7276
1565	39.5600	11.6101	1614	40.1746	11.7300
1566	39.5727	11.6126	1615	40.1870	11.7325
1567	39.5853	11.6151	1616	40.1995	11.7349
1568	39.5979	11.6175	1617	40.2119	11.7373
1569	39.6106	11.6200	1618	40.2243	11.7397
1570	39.6232	11.6225	1619	40.2367	11.7421
1571	39.6358	11.6249	1620	40.2492	11.7446
1572	39.6484	11.6274	1621	40.2616	11.7470
1573	39.6610	11.6299	1622	40.2740	11.7494
1574	39.6736	11.6323	1623	40.2864	11.7518
1575	39.6862	11.6348	1624	40.2988	11.7542
1576	39.6988	11.6372	1625	40.3112	11.7566
1577	39.7114	11.6397	1626	40.3236	11.7590
1578	39.7240	11.6422	1627	40.3360	11.7614
1579	39.7366	11.6446	1628	40.3484	11.7639
1580	39.7492	11.6471	1629	40.3608	11.7663
1581	39.7617	11.6495	1630	40.3732	11.7687
1582	39.7743	11.6520	1631	40.3856	11.7711
1583	39.7869	11.6544	1632	40.3980	11.7735
1584	39.7994	11.6569	1633	40.4103	11.7759
1585	39.8120	11.6594	1634	40.4227	11.7783
1586	39.8246	11.6618	1635	40.4351	11.7807
1587	39.8371	11.6643	1636	40.4474	11.7831
1588	39.8497	11.6667	1637	40.4598	11.7855
1589	39.8622	11.6692	1638	40.4722	11.7879
1590	39.8748	11.6716	1639	40.4845	11.7903
1591	39.8873	11.6740	1640	40.4969	11.7927
1592	39.8998	11.6765	1641	40.5092	11.7951
1593	39.9124	11.6789	1642	40.5215	11.7975
1594	39.9249	11.6814	1643	40.5339	11.7999
1595	39.9374	11.6838	1644	40.5462	11.8023
1596	39.9499	11.6863	1645	40.5585	11.8047
1597	39.9624	11.6887	1646	40.5709	11.8071
1598	39.9749	11.6911	1647	40.5832	11.8094
1599	39.9874	11.6936	1648	40.5955	11.8118
1600	40.0000	11.6960	1649	40.6078	11.8142
1601	40.0124	11.6985	1650	40.6201	11.8166
1602	40.0249	11.7009	1651	40.6324	11.8190
1603	40.0374	11.7033	1652	40.6448	11.8214
1604	40.0499	11.7058	1653	40.6571	11.8238
1605	40.0624	11.7082	1654	40.6693	11.8261
1606	40.0749	11.7106	1655	40.6816	11.8285
1607	40.0874	11.7131	1656	40.6939	11.8309
1608	40.0998	11.7155	1657	40.7062	11.8333
1609	40.1123	11.7179	1658	40.7185	11.8357

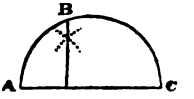
Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
1659	40.7308	11.8381	1694	41.1582	11.9207
1660	40.7430	11.8404	1695	41.1703	11.9231
1661	40.7553	11.8428	1696	41.1825	11.9254
1662	40.7676	11.8452	1697	41.1946	11.9278
1663	40.7798	11.8476	1698	41.2067	11.9301
1664	40.7921	11.8499	1699	41.2189	11.9324
1665	40.8044	11.8523	1700	41.2310	11.9348
1666	40.8166	11.8547	1701	41.2431	11.9371
1667	40.8289	11.8571	1702	41.2553	11.9395
1668	40.8411	11.8594	1703	41.2674	11.9418
1669	40.8533	11.8618	1704	41.2795	11.9441
1670	40.8656	11.8642	1705	41.2916	11.9465
1671	40.8778	11.8665	1706	41.3037	11.9488
1672	40.8900	11.8689	1707	41.3158	11.9511
1673	40.9023	11.8713	1708	41.3279	11.9535
1674	40.9145	11.8736	1709	41.3400	11.9558
1675	40.9267	11.8760	1710	41.3521	11.9581
1676	40.9389	11.8784	1711	41.3642	11.9605
1677	40.9511	11.8807	1712	41.3763	11.9628
1678	40.9633	11.8831	1713	41.3884	11.9651
1679	40.9756	11.8854	1714	41.4004	11.9675
1680	40.9878	11.8878	1715	41.4125	11.9698
1681	41.0000	11.8902	1716	41.4246	11.9721
1682	41.0121	11.8925	1717	41.4366	11.9744
1683	41.0243	11.8949	1718	41.4487	11.9768
1684	41.0365	11.8972	1719	41.4608	11 9791
1685	41.0487	11.8996	1720	41.4728	11.9814
1686	41.0609	11.9019	1721	41.4849	11.9837
1687	41.0731	11.9043	1722	41.4969	11.9860
1688	41.0852	11.9066	1723	41.5090	11.9884
1689	41.0974	11.9090	1724	41.5210	11.9907
1690	41.1096	11.9113	1725	41.5331	11.9930
1691	41.1217	11.9137	1726	41.5451	11.9953
1692	41.1339	11.9160	1727	41.5571	11.9976
1693	41.1460	11.9184	1728	41.5692	12.0000

To find the root of a number, consisting of integers and decimals.

RULE.—Multiply the difference between the root of the integer part of the given number, and the root of the next higher integer number, by the decimal part of the given number, and add the product to the root of the integer number given; the sum will be the root of the number required, correct in all cases of the square root to 3 places of decimals, and in the cube root to 7.

PROBLEM VII.

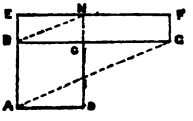
To find a mean proportional between two given right lines, or the side of a square equal to a given rectangle.



Upon a right line as a diameter equal to both given lines, describe the semicircle A B C, and where the two lines meet, or between their respective lengths, erect a perpendicular to the semicircle at B, and the perpendicular will be the mean proportion or side of the required square, equal to the given rectangle.

PROBLEM VIII.

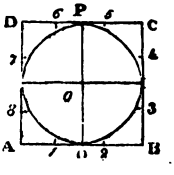
To produce a rectangle equal to a given square.



Suppose *a b c* and *d* be the given square, also *b e* one end of the required rectangle, draw *e f* parallel to *b c*, join *b n*, continue the side of the square *b c*, and draw the line *a g* parallel with *b n*, until it intersects at *g*, then *b g* is the side of the rectangle required.

PROBLEM IX.

To circumscribe a square about a given circle.



Draw two diameters at right angles as *m n* and O P; from *m n*, O P, as centres, with the radius of the circle, describe arcs cutting each other in A B C and D; join A B, B C, C D, D A, and A B C D will be the square required.

And from A as a centre, with the distance A *o*, cut the lines A B, A D, in 2 and 7; from B as a centre cut the lines B A, B C, in 1 and 4; from C as a centre cut the lines C B, C D, in 3 and 6; and from D as a centre cut the lines D C, D A, in 5 and 8; join 1, 8; 2, 3; 4, 5; and 6, 7; and 1, 2, 3, 4, 5, 6, 7, 8, will be a regular octagon.

PROBLEM X.

Upon a right line to describe an octagon.

On the extremities of one side A B, erect the perpendiculars A F and B E; continue the line A B to A *m* and B *n*, forming the angles A *m r*, and B *n s*; bisect the angles with the lines A H and B C; make each of those lines equal to A B; make H G and C D the same length, and parallel to A F and B E; from G and D as centres with the radius A B, describe arcs cutting A F and B E; join G F, F E, and E D, then A B C D E F G H will be the octagon required.

PROBLEM XI.

In a given circle to inscribe any regular polygon.

Divide the diameter A B into as many equal parts as the polygon is required to have sides; from A and B as centres, with the distance A B, describe arcs cutting each other in C; draw a line through the second division, meeting the circumference at D; join A D, and it will be the side of the polygon required.

PROBLEM XII.

To find the side of a square that shall be any number of times the area of a given square.

Let A B C D be the given square, then will the diagonal B D be the side of a square A E F G, double in area to the given square A B C D; and if the diagonal be drawn from B to G, it will be the side of a square A H K L, three times the area of the square A B C D, or the diagonal B L will equal the side of a square four times the area of the square A B C D, &c.

PROBLEM XIII.

To find the diameter of a circle that shall be any number of times the area of a given circle.

Let A B C D be the given circle, draw the two diameters A B and C D at right angles to each other, and the chord A D will be the radius of the circle *o* P, twice the area of the given circle nearly; and half the chord will be the radius of a circle that will contain half the area, &c.

PROBLEM XIV.

To divide a given circle into any number of co-centric parts equal to each other.

Upon the radius A B describe the semicircle A *e d* B; divide A B into the proposed number of equal parts, as 1, 2, &c.; erect the perpendiculars 1 *e*, 2 *d*, &c., meeting the semicircle in *e* and *d*; then from the centre A, and radii A *e* A *d*, &c., describe circles; so shall the circle be divided into the proposed number of equal parts, as required.

PROBLEM XV.

To find the side of a square nearly equal in area to a given circle.

Draw the two diameters A B and C D at right angles to each other, bisect the radius O C by a line from one end of the diameter at A, meeting the circumference in E, then will the line A E be the side of a square nearly equal in area to the given circle.

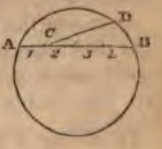
And if the line E F be drawn parallel to C D, it will be $\frac{1}{4}$ of the circumference nearly.

Or three times the diameter A B or C D, and once the versed sine Q H, of the angle A O D, will be the circumference nearly.

PROBLEM XVI.

To find a right line that shall be nearly equal to any given arc of a circle.

Divide the chord A B into four equal parts, set one part on the circumference from B to D, draw a line from C, the first division on the chord; and twice the length of the line C D will be the length of the arc nearly.



PROBLEM XVII.

To describe an ellipsis, the transverse and conjugate diameters being given.

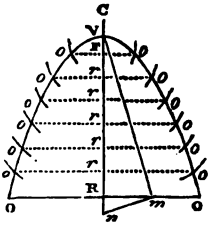
From *o*, as a centre, with the difference of the transverse and conjugate semi-diameters, set off *o c* and *o d*; draw the diagonal *c d*, and continue the line *o c* to *k*, by the addition of half the diagonal *c d*, then will the distance *o k* be the radius of

the centres that will describe the ellipsis; draw the lines A B, C D, C E, and B H, cutting the semi-diameters of the ellipsis in the centres *k l m n;* then with the radius *m s* describe the arcs D H and A E; also, with the radius *n r* describe the arcs E D and A H, which will be the ellipsis required.

PROBLEM XVIII.

To describe a parabola, any ordinate to the axe and its abscissa being given.

Let V R and R *o* be the given abscissa and ordinate; bisect R *o* in *m*, join V *m*, and draw *m n* perpendicular to it, meeting the axe in *n;* make V C and V F each equal to R *n*, then will F be the focus of the curve.



Take any number of points, *r*, *r*, &c., in the axis, and draw the double ordinates of an indefinite length.

From F, as a centre, with the radii C F, C *r*, &c., describe arcs cutting the corresponding ordinates in the points *o o o o*, &c., and the curve *o* V *o*, drawn through all the points of intersection, will be the parabola required.

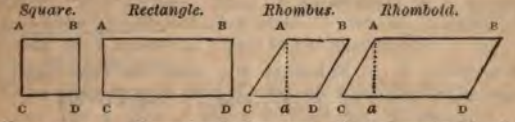
MENSURATION OF SUPERFICIES.

The area or superficial content of any figure is the space contained within length and breadth, without having any regard to the thickness.

PROBLEM I.

To find the area of any parallelogram, whether it be a square, a rectangle, a rhombus, or a rhomboid.

RULE.—Multiply the length by the breadth or height, and the product will be the area.



EXAMPLE.—Required the area of a rhomboid whose length A B = 20.5, and breadth *a* A = 11.75.

$$20.5 \times 11.75 = 240.875 \text{ the area.}$$

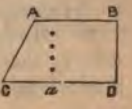
PROBLEM II.

To find the area of a trapezoid.

RULE.—Add together the two parallel sides, multiply their sum by the breadth or height, and half the product is the area.

EXAMPLE.—Required the area of a trapezoid whose sides A B and C D are 14.5 and 10.25, and breadth, *a* A, = 7.25.

$$\frac{14.5 + 10.25 \times 7.25}{2} = 89.71875$$



the area.

PROBLEM III.

To find the area of a triangle.

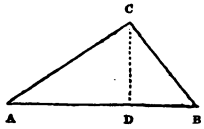
RULE.—Multiply one of its sides as a base by a perpendicular let fall from the opposite angle, and take half the product for the area.

Or, Subtract each side separately from half the sum of the sides, multiply the half sum of the sides by the three remainders, and the square root of the product will be the area.

EXAMPLE 1.—Required the area of a triangle A B C whose base A B = 16.5, and perpendicular D C = 10.25.

$$\frac{16.5 \times 10.25}{2} = 84.5625$$

the area.



EXAMPLE 2. — What is the area of that triangle whose three sides are 8, 12, and 16 respectively?

$$\frac{8 + 12 + 16}{2} = 18,$$ the half sum of the sides;

then, 18 18 18
8 12 16
— — —
10 6 2 and $\sqrt{18 \times 10 \times 6 \times 2} = 46.47$

the area.

PROBLEM IV.

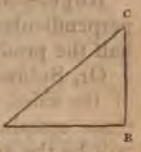
If any two sides of a right-angled triangle be given, the third side may be found by the following rules.

1.—To the square of the base add the square of the perpendicular; and the square root of the sum will be the hypotenuse or longest side.

2.—Multiply the sum of the hypotenuse, and one side by their difference; and the square root of the product will be the other side.

EXAMPLE 1.—Given the base A B = 16, and perpendicular B C = 12; required the length of the hypotenuse A C.

$\sqrt{16^2 + 12^2} = 20$ the length of the hypotenuse A C.



EXAMPLE 2.—Given the base A B = 16, and hypotenuse A C = 20; required the length of the perpendicular B C.

$\sqrt{20 + 16} \times 4 = 12$, length of the perpendicular B C.

NOTE.—The diagonal line, or hypotenuse in a square, is equal to the square root of twice the square of the side. And the side of a square is equal to the square root of half the square of its diagonal.

Thus, suppose each side of a square equal 12 feet:—

$12^2 \times 2 = \sqrt{288} = 16.9705$ feet, the diagonal. Or,

$\frac{16.9705^2}{2} = \sqrt{144} = 12$ feet, the length of each side.

PROBLEM V.

To find the area of any regular polygon.

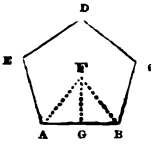
RULE.—Multiply the sum of its sides by a perpendicular drawn from its centre to one of its sides, and take half the product for the area.

Or, Multiply the square of the side of a polygon (from three to twelve sides) by the numbers in the fourth column of the table for polygons, opposite the number of sides required, and the product will be the area nearly.

EXAMPLE 1.—Required the area of the regular pen-

tagon A B C D E, each side being 7.5, and perpendicular F G = 6.4.

$$\frac{7.5 \times 5 \times 6.4}{2} = 120 \text{ the area.}$$



EXAMPLE 2.—What is the area of a regular hexagon, each side being 8.75 in length?

$8.75^2 \times 2.598 = 199.009375$ the area.

Table of multipliers for polygons from three to twelve sides.

Names.	*Sides.*	*Multipliers.*	*Multipliers.*	*Multipliers.*	*Areas.*
Trigon	3	2	1.73	.579	.433
Tetragon.....	4	1.41	1.412	.705	1.000
Pentagon.....	5	1.238	1.174	.852	1.72
Hexagon	6	1.156	= Radius.	= Length of side.	2.598
Heptagon...	7	1.11	.867	1.16	3.634
Octagon	8	1.08	.765	1.307	4.828
Nonagon.....	9	1.062	.681	1.47	6.1818
Decagon.....	10	1.05	.616	1.625	7.694
Undecagon...	11	1.04	.561	1.777	9.365
Dodecagon...	12	1.037	.515625	1.94	11.196

1.—*The breadth of a polygon given, to find the radius of a circle to contain that polygon.*

RULE.—Multiply half the breadth of the polygon by the numbers in the first column opposite to its name, or number of sides, and the product will be the radius of a circle to contain that polygon.

And if the polygon have an unequal number of sides, the half breadth is accounted from its centre to one of

2.—*The radius of a circle given, to find the length of side.*

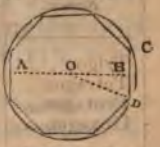
RULE.—Multiply the radius of any circle by the numbers in the second column opposite the polygon required; and the product will be the length of side nearly that will divide that circle into the proposed number of sides. And,

3.—*The length of side given, to find the radius.*

RULE.—Multiply the given length of side by the numbers in the third column opposite the polygon required; and the product will be the radius of a circle to contain that polygon.

EXAMPLE 1.—Required the radius of a circle to contain an octagon, whose breadth A B = 18.5 inches.

Half of 18.5 = 9.25, and 9.25 × 1.08 = 9.99 or ten inches nearly, the radius of the circle O D.



EXAMPLE 2.—Given the radius O D = 9.99 inches; required the length of side D C.

9.99 × 7.65 = 7.64235, the length of side.

EXAMPLE 3.—Given the length of side D C = 7.64235; required the radius D O.

7.64235 × 1.307 = 9.98855145, or 9.99 in. nearly.

PROBLEM VI.

Having the diameter of a circle given, to find the circumference; or the circumference given, to find the diameter.

RULE 1.—As 7 is to 22, so is the diameter to the circumference.

Or, as 22 is to 7, so is the circumference to the diameter.

2.—As 1 is to 3.1416, so is the diameter to the circumference.

Or, as 3.1416 is to 1, so is the circumference to the diameter.

EXAMPLE 1.—Required the circumference of a circle when the diameter is 23.5.

$$\frac{23.5 \times 22}{7} = 73\tfrac{6}{7},$$ the circumference.

EXAMPLE 2.—The circumference of a circle is $73\frac{6}{7}$, required the diameter.

$$\frac{73\frac{6}{7} \times 7}{22} = 23.5,$$ the diameter.

EXAMPLE 3.—Required the circumference of a circle whose diameter is 30.

$3.1416 \times 30 = 94.248$, the circumference.

EXAMPLE 4.—What is the diameter of a circle when the circumference is 94,248 ?

$94.248 \div 3.1416 = 30$, the diameter.

NOTE.—If the vessel is to be constructed with two ends, divide four times the required solidity by 3.1416, and the cube root of the quotient equal both length and diameter in equal terms.

Thus, $\frac{600 \times 4}{3.1416} = \sqrt[3]{764} = 9.142$ diameter and depth required.

PROBLEM VII.

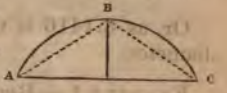
To find the length of any arc of a circle.

RULE.—Subtract the chord of the whole arc from eight times the chord of half the arc; and $\frac{1}{3}$ of the remainder is the length of the arc nearly.

EXAMPLE.—Required the length of the arc A B C;

the chord of half the arc A B = 19.8, and chord of the whole arc A C = 34.4.

$19.8 \times 8 = 158.4$ and $\frac{158.4 - 34.4}{3} = 41.33$, the length of the arc.



PROBLEM VIII.

To find the diameter of a circle, by having the chord and verse sine given.

RULE.—Divide the square of half the chord by the versed sine, to the quotient of which add the versed sine, and the sum will be the diameter.

Or, if the sum of the squares of the semichord and versed sine be divided by the versed sine, the quotient will be the diameter of the circle to which that segment corresponds.

EXAMPLE.—Given the chord A B = 24, and versed sine C D = 8; required the diameter of the circle C E.

Half the chord = 12 and $12^2 \div 8 = 18 + 8 = 26$, the diameter.

Or, $\frac{12^2 + 8^2}{8} = 26$, as before.

Table of versed sines, whereby to ascertain the diameters of circles corresponding to any segment or part of a circle having a chord of three feet.

Length of chord three feet.	Versed sine in inches.	Corresponding diameter in ft. and in.	Versed sine in inches.	Corresponding diameter in ft. and in.	Versed sine in inches.	Corresponding diameter in ft. and in.
	Inches.	Ft. & In.	Inches.	Ft. & In.	Inches.	Ft. & In.
	6	3 0	2 1/2	10 0	1 1/2	18 0
	5 1/2	3 3	2 3/8 1/16	10 3	1 7/16 3/32	18 6
	5 1/4 & 1/32	3 6	2 5/16 1/16	10 6	1 7/16 1/32	19 0
	5 1/32	3 9	2 1/4 1/16	10 9	1 7/16	19 6
	4 31/32	4 0	2 3/16 1/16	11 0	1 3/8 3/32	20 0
	4 15/16	4 3	2 1/8 1/16	11 3	1 3/8 1/32	21 0
	4 7/8	4 6	2 1/16 1/16	11 6	1 3/8	22 0
	4 13/16	4 9	2 1/16	11 9	1 5/16 1/32	23 0
	4 3/4	5 0	2 1/16	12 0	1 5/16	24 0
	4 11/16	5 3	2 1/8 1/16	12 6	1 1/4	25 0
	4 5/8	5 6	2 3/16 1/16	13 0	1 3/16	26 0
	4 9/16	5 9	2 1/4 1/16	13 6	1 inch.	27 0
	4 1/2	6 0	1 15/16 1/16	14 0	15/16	28 0
	4 7/16	6 3	1 7/8 1/16	14 6	7/8	29 0
	4 3/8	6 6	1 13/16 1/16	15 0	13/16	30 0
	4 5/16	6 9	1 3/4	15 6	3/4	35 0
	4 1/4	7 0	1 11/16 1/16	16 0	11/16	40 0
	4 3/16	7 3	1 5/8 1/16	16 6	5/8	45 0
	4 1/8	7 6	1 9/16 1/16	17 0	9/16	50 0
	4 1/16	7 9	1 1/2 1/16	17 6		

Table of the relative proportions of the circle, its equal and inscribed squares.

1.	The Diameter of a circle	× .8862	=	the side of an equal square.
2.	„ Circumference	× .2821		
3.	„ Diameter	× .7071	=	the side of an inscribed square.
4.	„ Circumference	× .2251		
5.	„ Area	× .6366	=	the content of an inscribed square.
6.	„ Side of inscribed square circumscribing circle.	× 1.4142	=	the diameter of a
7.	„ Side of inscribed square a circumscribing circle.	× 4.443	=	the circumference of
8.	„ Side of a square equal circle.	× 1.128	=	the diameter of an
9.	„ Side of a square an equal circle.	× 3.545	=	the circumference of

Examples illustrative of the preceding table.

EXAMPLE 1.—The diameter of a circle is 12.5 ; required the side of a square equal in area to the given circle.

12.5 × .8862 = 11.07750, side of equal square.

Ex. 2.—The circumference of a circle being 53.4 ; required the side of a square equal in area.

53.4 × .2821 = 15.06414, side of equal square.

Ex. 3.—The diameter of a circle being 18 ; required the side of the greatest square that can be inscribed therein.

18 × .7071 = 12.7278, side of inscribed square.

Ex. 4.—The circumference of a circle is 86 ; required the side of inscribed square.

86 × .2251 = 19.3586, side of inscribed square.

Ex. 5.—The area of a circle being 371.5 ; required the area of the greatest square that can be inscribed within the circle.

371.5 × .6366, = 236.49690, area of the required square.

Ex. 6.—The side of a square being 19.375 ; required the diameter of its circumscribing circle.

19.375 × 1.4142 = 27.4001250, diameter.

Ex. 7.—Required the circumference of a circle to circumscribe a square, each side being 19.375.

19.375 × 4.443 = 86.083125, circumference of the circle required.

Ex. 8.—The side of a square being 13.5 ; required the diameter of a circle equal in area to the given square.

13.5 × 1.128 = 152,280, diameter of the circle required.

Ex. 9.—The side of a square being 13.5 ; required the circumference of a circle equal in area to the given square.

13.5 × 3.545 = 47.8575, circumference of the circle required.

Some of the properties of a circle.

1.—It is the most capacious of all plain figures, or contains the greatest area within the same perimeter or outline.

2.—The areas of circles are to each other as the squares of their diameters, or of their radii.

3.—Any circle whose diameter is double that of another, contains four times the area of the other.

4.—The area of a circle is equal to the area of a triangle whose base is equal to the circumference, and perpendicular equal to the radius.

5.—The area of a circle is equal to the rectangle of its radius, and a right line equal to half its circumference.

6.—The area of a circle is to the square of the diameter as .7854 to 1 ; or, multiply half the circumference by half the diameter, and the product will be the area.

EXAMPLE 1.—Required the area of a circle, the diameter being 30.5.

$30.5^2 \times .7854 = 730.618350$, the area required.

EXAMPLE 2.—What is the area of a circle when the diameter is 1 ?

In this case the circumference is 3.1416, half of which is 1.5708, and half of 1 = .5 ; then 1.5708 × .5 = .7854, the area.

PROBLEM IX.

Having the area of a circle given, to find the diameter.

RULE.—As 355 is to 452, so is the area to the square of the diameter.

Or, Multiply the square root of the area by 1.12837, and the product will be the diameter.

EXAMPLE.—Required the diameter of that circle whose area is 122.71875.

$$\frac{\sqrt{122.71875 \times 452}}{355} = 12.5 \text{ diameter.}$$

Or, $\sqrt{122.71875} = 11.077$; and $11.077 \times 1.12837 = 12.49895$, or 12.5 diameter.

PROBLEM X.

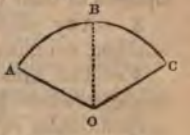
To find the area of a sector of a circle.

RULE.—Multiply the length of the arc by the radius of the circle, and half the product will be the area.

EXAMPLE.—Required the area of a sector of a circle whose arc A B C = 26.666, and radius B O = 16.9,

$$\frac{26.666 \times 16.9}{2} = 225.3277$$

the area.



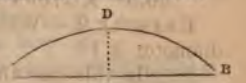
PROBLEM XI.

To find the area of a segment of a circle.

RULE.—Multiply the versed sine by the decimal .626, to the square of the product add the square of half the chord; multiply twice the square root of the sum by $\frac{2}{3}$ of the versed sine; and the product will be the area.

EXAMPLE.—Required the area of a segment of a circle whose chord A B = 48, and versed sine C D = 18.

$18 \times .626 = 11.268^2$ = 126.967824; which add to 576, being the square of half the chord = 702967824, twice the square root of which is 53.026 × 12; being $\frac{2}{3}$ of the versed sine = 636.312 the area.



The following is a near approximate to the preceding rule:

To the cube of the versed sine, divided by twice the length of the chord, add $\frac{3}{5}$ of the product of the chord, multiplied by the versed sine; and the sum will be the area of the segment nearly. Take the last example:—

Versed sine = 18, and chord 48, then, $\frac{18^3}{48 \times 2} = 60.7$

And $\frac{48 \times 18 \times 2}{3} = 576 + 60.7 = 636.7$, the area nearly.

Or, the area of a segment may be found by finding the area of a sector having the same radius as the segment; then deducting the area of the triangle leaves the area of the segment.

PROBLEM XII.

To find the area of a circular ring or space included between two concentric circles.

RULE.—Add the inside and outside diameters together, multiply the sum by their difference, and by .7854; and the product will be the area.

EXAMPLE.—The diameters of two concentric circles, A B and C D, are 10 and 6; required the area of the ring or space contained between them.

$\overline{10 + 6} \times 4 \times .7854 =$ 50.2656 the area.

PROBLEM XIII.

To find the area of an ellipsis.

RULE.—Multiply the transverse or longer diameter by the conjugate or shorter diameter, and by .7854, and the product will be the area.

EXAMPLE.—Required the area of an ellipsis whose longer diameter A B = 12, and shorter diameter C D = 9.

$12 \times 9 \times .7854 =$ 84.8232 the area.

NOTE.—If half the sum of the two diameters be multiplied by 3.1416, the product will be the circumference of the ellipsis Thus, $12 + 9 = 21$, and $\frac{3.1416 \times 21}{2} = 36.1384$ the circumference.

MENSURATION OF SOLIDS.

By solids are meant all bodies, whether solid, fluid, or bounded space, that can be comprehended within length, breadth, and thickness.

PROBLEM I.

To find the convex surface and solid content of an upright cylinder.

RULE 1.—Multiply the circumference of the base by the height of the cylinder, and the product is the convex surface.

RULE 2.—Multiply the area of the base by the height of the cylinder, and the product is the solid content.

EXAMPLE 1.—Required the convex surface of the cylinder A B C D, whose base A B = 32 inches, and perpendicular height B C = 6 feet.

$3.1416 \times 32 \times 72$ inches = 7238.2464 square or superficial inches, and $7238.2464 \div 144 =$ 50.2658 superficial feet.

EXAMPLE 2.—Required the solid content, in cubic inches and cubic feet, of the cylinder as above.

$32^2 \times .7854 \times 72 = 57905.9712$ cubic inches, and $57905.9712 \div 1728 = 33.5104$ cubic feet.

EXAMPLE 3.—Suppose the cylinder A B C D be intended to contain a fluid, and that the sides and bottom are each one inch in thickness, how many imperial gallons would it contain?

$32 - 2 = 30$ inches diameter; and $72 - 1 = 71$ inches deep; then $\frac{30^2 \times .7854 \times 71}{277.274} =$ 181 gallons.

Or, $50187.06 \times .003607 = 181$, as before.

PROBLEM II.

To determine the dimensions of any cylindrical vessel, whereby to contain the greatest cubical contents, bounded by the least superficial surface.

RULE.—Multiply the given cubical contents by 2.56, and the cube root of the product equal the diameter, and half the diameter equal the depth.

EXAMPLE.—Suppose a cylindrical vessel is to be made so as to contain 600 cubic feet, and of such dimensions as to require the least possible materials by which it is constructed, what must be its depth and diameter?

$600 \times 2.56 = \sqrt[3]{1536} = 11.5379$ feet diameter, and $11.5379 \div 2 = 5.76895$ feet the depth.

NOTE.—If the vessel is to be constructed with two ends, then the cube root of four times the solidity divided by 3.1416 equal both the length and diameter, so as to expose the least possible surface, or be composed of the least possible materials, of which to be constructed.

PROBLEM III.

To find the surface and solid content of a cone or pyramid.

RULE 1.—Multiply the circumference of the base by the slant height, and half the product will be the slant surface, to which add the area of the base, and the product will be the whole surface.

RULE 2.—Multiply the area of the base by the per-

pendicular height, and $\frac{1}{3}$ of the product will be the solid content.

EXAMPLE 1.—Required the convex surface of a cone whose base A B = 20 inches, and slant height B D = 29.5.

$$\frac{3.1416 \times 20 \times 29.5}{2} = 926.772$$

square inches, and divided by 144 = 6.435 superficial feet.

EXAMPLE 2.—Required the solidity of the cone as above, the perpendicular C D being 28 inches.

$$\frac{20^2 \times .7854 \times 28}{3} = 2932.16$$ cubic inches, and divided by 1728 = 1.697 cubic feet.

PROBLEM IV.

To find the surface of the frustum of a cone or pyramid.

RULE.—Multiply the sum of the perimeters of the two ends by the slant height, and half the product will be the slant surface; to which add the areas of the two ends, and the product will be the whole surface.

EXAMPLE.—Required the convex surface of the frustum of a cone A B C D, whose base A B = 20 inches, the slant height B C = 19, and top end C D = 11.

$$\frac{3.1416 \times 20 + 3.1416 \times 11 \times 19}{2}$$

= 925,2012 square inches, and divided by 144 = 6.425 feet nearly.

PROBLEM V.

To find the solid content of the frustum of a cone.

RULE.—To the product of the diameters of the two ends, add the sum of their squares; multiply this sum by the perpendicular height and by .2618, the product is the solid content.

EXAMPLE 1.—Required the solid content of the frustum in Problem IV, whose perpendicular E F = 18 inches.

$20 \times 11 = 220$, and $220 + 20^2 + 11^2 \times 18 \times .2618 = 3491.8884$ cubic inches, and divided by $1728 = 2.0208$ cubic feet nearly.

EXAMPLE 2.—Required the content, in imperial gallons, of the inverted frustum of a cone A B C D, whose inner dimensions are $3\frac{1}{2}$ feet deep, 18 inches diameter at bottom, and 22 inches diameter at top.

$22 \times 18 = 396$ and $\overline{396 + 22^2 + 18^2} \times 42 \times .2618 = \frac{13238.7024}{277.274} =$ 47.745 gallons nearly.

Or, $13238{,}7024 \times 0.00360654 = 47.75$ gallons nearly, as before.

PROBLEM VI.

To find the solid content of the frustum of a pyramid.

RULE.—To the sum of the areas of the two ends add the square root of their product; multiply this sum by the perpendicular height, and $\frac{1}{3}$ of the product is the solid content.

EXAMPLE.—Required the solid content of the frustum of a pyramid A B C D, whose perpendicular

height = 24 inches, the area of the base = 144 inches, and area of the top end = 64.

$144 + 64 = 208$ and $\sqrt{144 \times 64} = 96$, then $\frac{208 + 96 \times 24}{3} = 2432$ cubic inches, and $\div 1728 = 1.4074$ cubic feet nearly.

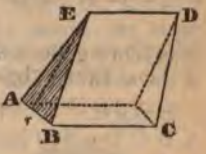
PROBLEM VII.

To find the solidity of a wedge.

RULE.—To the length of the wedge add twice the length of the base; multiply that sum by the height, and by the breadth of the base, and one-sixth of the product will be the solidity.

EXAMPLE.—Required the content in cubic inches of the wedge A B C D E, whose base A B C = 12 inches long and 4 inches broad, the length of the edge D E = 10 inches, and perpendicular height r E = 20 inches.

$\frac{10 + 24 \times 20 \times 4}{6} = 453.33$ cubic inches.



PROBLEM VIII.

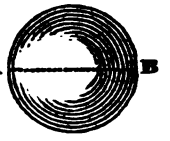
To find the convex surface and solid content of a sphere or globe.

RULE 1.—Multiply the square of the diameter by 3.1416, the product will be the convex superficies.

RULE 2.—Multiply the cube of the diameter by .5236, and the product is the solid content.

EXAMPLE 1.—Required the convex surface of a sphere, whose diameter A B = 25½ inches.

$25.5^2 \times 3.1416 = 2042.8254$ square inches, $\div 144 = 14.1862$ square or superficial feet.



EXAMPLE 2.—Required the solid content of a sphere, whose diameter A B = 25½ inches.

$25.5^3 \times .5236 = 8682.00795$ cubic inches, $\div 1728 = 5.0243$ cubic feet.

PROBLEM IX.

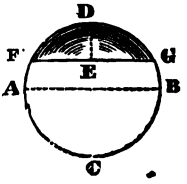
To find the convex surface and solid content of the segment of a sphere.

RULE 1.—Multiply the height of the segment by the whole circumference of the sphere, and the product is the curved surface.

RULE 2.—Add the square of the height to three times the square of the radius of the base; multiply that sum by the height, and by .5236, and the product is the solid content.

EXAMPLE 1.—The diameter A B of the sphere A B C D = 20 inches; what is the convex surface of that segment of it whose height E D = 8 inches?

$3.1416 \times 20 \times 8 = 502.656$ square inches $\div 144 = 3.49$ superficial feet.



EXAMPLE 2.—The base F G of the segment F D G

= 18 inches, and perpendicular E D = 8, what is the solid content?

$8^2 = 64$, and $9^2 \times 3 = 243$, then $\overline{243 + 64} \times 8 \times .5236 = 1285.9616$ cubic inches $\div 1728 = .7441$ cubic feet.

EXAMPLE 3.—Suppose A B C D to be a sugar pan, and that the diameter of the mouth A B is 4 feet, the depth D C being 25 inches, how many imperial gallons will it contain?

$25^2 = 625$, and $24^2 \times 3 = 1728$, then $\overline{1728 + 625} \times 25 \times .5236 = 30800.77$

$277.274 = 111.084$ gallons

PROBLEM X.

To find the solidity of a spheroid.

RULE.—Multiply the square of the revolving axis by the fixed axis, and by .5236, and the product will be the solidity.

EXAMPLE 1.—Required the solid content of the prolate spheroid A B C D, whose fixed axis A C is 50, and revolving axis B D 30

$30^2 \times 50 \times .5236 = 23562$, the solidity.

EXAMPLE 2.—What is the solid content of an oblate spheroid, the fixed axis being 30, and revolving axis 50?

$50^2 \times 30 \times .5236 = 39270$, the solid content.

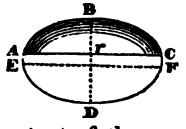
PROBLEM XI.

To find the solidity of the segment of a spheroid when the base is circular or parallel to the revolving axis.

RULE.—From triple the fixed axis take double the height of the segment; multiply the difference by the square of the height, and by .5236; then say, as the square of the fixed axis is to the square of the revolving axis, so is the former product to the solidity.

EXAMPLE 1.—Required the solid content of the segment A B C, whose height B r is 10; the revolving axis E F being 40, and fixed axis B D 25.

$\overline{25 \times 3} - \overline{10 \times 2} = 55$ and $55 \times 10^2 \times .5236 = 2879.8$; then, as $25^2 : 40^2 :: 2879.8 : 7372.3$ nearly.



EXAMPLE 2.—What is the solid content of the segment of a spheroid whose height = 20 inches, the revolving axis being 25, and fixed axis 50?

$\overline{50 \times 3} - \overline{20 \times 2} = 110$, and $110 \times 20^2 \times .5236 = 23038.4$; then, as $50^2 : 25^2 :: 23038.4 : 5759.6$ inches, the solid content.

ROBLEM XII.

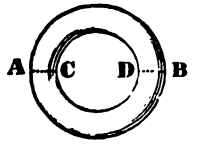
To find the convex surface and solid content of a cylindric ring.

RULE 1.—Multiply the thickness of the ring added to the inner diameter, by the thickness and by 9.8698, and the product will be the convex surface.

RULE 2.—To the thickness of the ring add the inner diameter; multiply that sum by the square of the thickness and by 2.4674, and the product will be the solid content.

EXAMPLE 1.—The thickness of a cylindric ring A C or D B = 2 inches, and inner diameter = 18, required the convex superficies.

$\overline{18 + 2} \times 2 \times 9.8698 =$ 394.792 square inches, and $\div$ 144 = 2.741 superficial feet nearly.

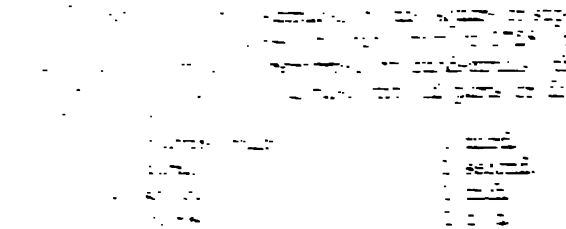


EXAMPLE 2.—Required the solid content of the ring as above.

$18 + 2 \times 2^2 \times 2.4674 = 197.392$ cubic inches and $\div$ 1728 = .114 cubic feet.

NOTE.—A cubic foot is equal to 1728 cubic inches.
or 2200 cylindrical inches.
or 3300 spherical inches.
or 6600 conical inches.

Also, the cubic foot being considered unity, or 1,
A cylinder 1 foot diameter, and 1 foot in length = .7854
A sphere 1 foot in diameter ..... = .5236
And a cone 1 foot diameter at the base and 1 foot in height ..... = .2619



This proceed in like manner with all the other denominations, and their sum will be the content.

EXAMPLE 1.—Required the superficial content of a board 12 feet 6 inches long and 1 foot $5\frac{1}{2}$ inches broad.

	F.	I.	
	12	6	
Multiplied by	1	5	6
	12	6	
	5	2	6
		6	3
Feet	18	2	9

When the two ends of a board or plank are of different breadths, add the two breadths together, and multiply the length by half the sum.

EXAMPLE 2.—A plank that is 1 foot 4 inches broad at one end, $11\frac{1}{2}$ inches broad at the other, and 18 feet 9 inches long, what is its superficial content?

$16 + 11\frac{1}{2} = 27\frac{1}{2} \div 2 = 13\frac{3}{4}$ inches.

	F.	I.		
Then	18	9		
$13\frac{3}{4}$ inches =	1	1	9	
	18	9		
	1	6	9	
	1	2	0	9
Feet	21	5	9	9

Superficial measure by the Engineer's Slide Rule.

When the length is given in feet, and the breadth in inches, the gauge point is 12 ; but if the dimensions are all inches, the gauge point is 144.

RULE.—Set the breadth upon B to the gauge point upon A, and against the length upon A is the content in square feet upon B.

EXAMPLE 1.—Required the number of square feet contained in a board $11\frac{1}{2}$ inches broad and 18 feet long.

Set 11.5 upon B to 12 upon A ; and against 18 upon A is 17.3 feet upon B.

The content of one board being found, the content of any number of the same dimensions may be found by setting 1 upon B to the content of the one found upon A; and against any number of boards upon B is the whole content upon A.

Find the content of 8 boards, each being 17.3 square feet.

Set 1 upon B to 17.3 upon A; and against 8 upon B is 138.4 feet upon A.

EXAMPLE 2.—If a board is 10 inches broad at one end, and 7 at the other, what must be its length to make a square foot?

$10 + 7 = 17 \div 2 = 8\frac{1}{2}$ inches. Set 8.5 upon B to 144 upon A; and against 1 upon B is 16.9 inches long upon A.

To find the solidity of timber.

The solid content of timber (according to custom) is found by multiplying the length by the square of the $\frac{1}{4}$ girth

EXAMPLE.—Required the content of a tree in cubic feet, whose girth in the middle is 84 inches, and length 25 feet 6 inches.

$84 \div 4 = 21$ inches $\frac{1}{4}$ girth.

	F.	I.		
and 21 inches =	1	9		
Multiplied by	1	9		
	1	9		
	1	3	9	
=	3	0	9	

	F.	I.		
Then	25	6		
Multiplied by	3	0	9	
	76	6		
	1	7	1	6
Feet	78	1	1	6

But a more expeditious method is obtained by means of the following

TABLE.

¼ Girt in Inches.	Area in Feet.	¼ Girt in Inches.	Area in Feet.	¼ Girt in Inches.	Area in Feet.
6	.250	12½	1.042	19	2.506
6¼	.272	12⅝	1.085	19½	2.640
6½	.294	12¾	1.129	20	2.777
6¾	.317	13	1.174	20½	2.917
7	.340	13¼	1.219	21	3.062
7¼	.364	13½	1.265	21½	3.209
7½	.390	13¾	1.313	22	3.362
7¾	.417	14	1.361	22½	3.516
8	.444	14¼	1.410	23	3.673
8¼	.472	14½	1.460	23½	3.835
8½	.501	14¾	1.511	24	4.000
8¾	.531	15	1.562	24½	4.168
9	.562	15¼	1.615	25	4.340
9¼	.594	15½	1.668	25½	4.516
9½	.626	15¾	1.722	26	4.694
9¾	.659	16	1.777	26½	4.876
10	.694	16¼	1.833	27	5.062
10¼	.730	16½	1.890	27½	5.252
10½	.766	16¾	1.948	28	5.444
10¾	.803	17	2.006	28½	5.640
11	.840	17¼	2.066	29	5.840
11¼	.878	17½	2.126	29½	6.044
11½	.918	17¾	2.187	30	6.250
11¾	.959	18	2.250		
12	1.000	18½	2.376		

RULE.—Multiply the area corresponding to the ¼ girth in inches by the length of the timber in feet; and the product is the solidity in feet and decimal parts.

EXAMPLE.—A piece of timber, 18 feet long and 14 inches square, how many cubic feet does it contain?

1.361 × 18 = 24.498 cubic feet.

The content of one board bei
any number of the same dime
setting 1 upon B to the conte
A; and against any number
whole content upon A.

Find the content of 8 boa
feet.

Set 1 upon B to
upon B is 138.4 feet

EXAMPLE 2.—If a b
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a square foot?

10 + 7 = 17
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To fi

The solid conte
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$\frac{1}{4}$ girth

EXAMPLE.—
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Rule.

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upon D, is the solid

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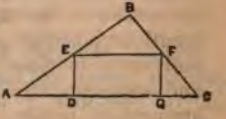
s $\frac{1}{4}$ girth?
upon A; and against 16
on C.

ion of the strongest beam that of a round piece of timber.

piece of timber
meter B D, and
ual parts, as B *l*
dicular *m* C, meet-
raw D C and C B;
ual and parallel to
equal and parallel to
ngle will be a section
quired.

greatest rectangle that can possibly be btained in a given triangle.

be a given triangle,
o of its sides, as
F, and to each end
lines at right angles
her side A C, and
ill be the rectangle



HE STRENGTH OF MATERIALS.

nowledge of the strength of materials is one of ost important, and at the same time one of the most ult subjects that the practical mechanic has to con- nd with, owing chiefly to the very different qualities f bodies of the same name; hence arise some doubts in selecting experiments whereon to build a data, there being scarcely two experiments made producing the same results. However, the following tables and rules are founded upon a mean of Messrs. Rennie, Barlow, and Telford's experiments, having found them to agree the best with practice, and my own experiments on similar bodies.

ON THE COHESIVE STRENGTH OF BODIES.

The cohesive strength of a body is that force with which it resists separation in the direction of its length, as in the case of ropes, &c.; and no reason can be assigned why the strength should not vary directly as the section of fracture, and is totally independent of the length in position, except so far as the weight of the body may increase the force applied: neglecting this, and supposing the body uniform in all its parts, the strength of bodies exposed to strains in the direction of their length, is directly proportionate to their transverse area, whatever be their figure, length, or position.

The following Table contains the result of experiments on the cohesive strength of various bodies in avoirdupois pounds;—also one-third of the ultimate strength of each body, this being considered sufficient, in most cases, for a permanent load.

Names of Bodies.	*Sq. Bar.*	*1 third.*	*Rnd. Bar.*	*1 third.*
WOODS.	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Boxwood	20000	6667	15708	5236
Ash	17000	5667	13357	4452
Teak	15000	5000	11781	3927
Fir	12000	4000	9424	3141
Beech	11500	3866	9032	3011
Oak	11000	3667	8639	2880
METALS.				
Cast iron	18656	6219	14652	4884
English wrt. iron	55872	18624	43881	14627
Swedish do do.	72064	24021	56599	18866
Blistered steel	133152	44384	104577	34859
Shear do.	124400	41366	97703	32568
Cast do.	134256	44752	105454	35151
Cast copper	19072	6357	14979	4993
Wrought do.	33792	11264	26540	8847
Yellow brass	17968	5989	14112	4704
Cast tin	4736	1579	3719	1239
Cast lead	1824	608	1432	477

PROBLEM I.

To find the ultimate cohesive strength of square, round, and rectangular bars, of any of the various bodies, as specified in the table.

RULE.—Multiply the strength of an inch bar, (as in the table,) of the body required, by the cross sectional area of square and rectangular bars, or by the square of the diameter of round bars; and the product will be the ultimate cohesive strength.

EXAMPLE 1.—A bar of cast iron being $1\frac{1}{2}$ inches square, required its cohesive power.

$$1.5 \times 1.5 \times 18656 = 41976 \text{ lbs.}$$

EXAMPLE 2.—Required the cohesive force of a bar of English wrought iron, 2 inches broad, and $\frac{3}{8}$ of an inch in thickness.

$$2 \times .375 \times 55872 = 41904 \text{ lbs.}$$

EXAMPLE 3.—Required the ultimate cohesive strength of a round bar of wrought copper, $\frac{3}{4}$ of an inch in diameter.

$$.75^2 \times 26540 = 14928.75 \text{ lbs.}$$

PROBLEM II.

The weight of a body being given, to find the cross sectional dimensions of a bar or rod capable of sustaining that weight.

RULE.—For square and round bars,—Divide the weight given by one-third of the cohesive strength of an inch bar, (as specified in the table,) and the square root of the quotient will be the side of the square, or diameter of the bar in inches.

And if rectangular, divide the quotient by the breadth, and the result will be the thickness.

EXAMPLE 1.—What must be the side of a square bar of Swedish iron to sustain a permanent weight of 18000 lbs?

$$\sqrt{\frac{18000}{24021}} = .86, \text{ or nearly } \frac{7}{8} \text{ of an inch square.}$$

EXAMPLE 2.—Required the diameter of a round rod of cast copper to carry a weight of 6800 lbs.

$$\sqrt{\frac{6800}{4993}} = 1{:}16 \text{ inches diameter.}$$

EXAMPLE 3.—A bar of English wrought iron is to be applied to carry a weight of 2760 lbs; required the thickness, the breadth being 2 inches.

$$\frac{2760}{18624} = .142 \div 2 = .071 \text{ of an inch in thickness.}$$

A TABLE

Showing the circumference of a rope equal to a chain made of iron of a given diameter, and the weight in tons that each is proved to carry; also the weight of a foot of chain made from iron of that dimension.

Ropes. Cir. in In.	*Chains. Dia. in Ins.*	*Proved to carry in tons.*	*Weight of a lineal foot in lbs. Avr.*
3	$\frac{1}{4}$ & $\frac{1}{16}$	1	1.08
4	$\frac{5}{16}$	2	1.5
$4\frac{3}{4}$	$\frac{3}{8}$ & $\frac{1}{16}$	3	2
$5\frac{1}{4}$	$\frac{7}{16}$	4	2.7
6	$\frac{1}{2}$ & $\frac{1}{16}$	5	3.3
$6\frac{1}{2}$	$\frac{9}{16}$	6	4
7	$\frac{5}{8}$ & $\frac{1}{16}$	8	4.6
$7\frac{1}{2}$	$\frac{11}{16}$	$9\frac{3}{4}$	5.5
8	$\frac{3}{4}$ & $\frac{1}{16}$	$11\frac{1}{4}$	6.1
9	$\frac{13}{16}$	13	7.2
$9\frac{1}{2}$	$\frac{7}{8}$ & $\frac{1}{16}$	15	8.4
$10\frac{1}{2}$	1 inch.	18	9.4

ON THE TRANSVERSE STRENGTH OF BODIES.

The *transverse strength* of a body is that power which it exerts in opposing any force acting in a perpendicular direction to its length, as in the case of beams, levers, &c., for the fundamental principles of which observe the following :—

That the transverse strength of beams, &c., is inversely as their lengths, and directly as their breadths, and square of their depths, and, if cylindrical, as the cubes of their diameters; that is, if a beam 6 feet long, 2 inches broad, and 4 inches deep, can carry 2000 lbs., another beam of the same material, 12 feet long, 2 inches broad, and 4 inches deep, will only carry 1000, being inversely as their lengths. Again, if a beam 6 feet long, 2 inches broad, and 4 inches deep, can sup-

port a weight of 2000 lbs., another beam of the same material, 6 feet long, 4 inches broad, and 4 inches deep, will support double that weight, being directly as their breadths;—but a beam of that material, 6 feet long, 2 inches broad, and 8 inches deep, will sustain a weight of 8000 lbs.; being as the square of their depths.

From a mean of experiments made, to ascertain the transverse strength of various bodies, it appears that the ultimate strength of an inch square, and an inch round bar of each, 1 foot long, loaded in the middle, and lying loose at both ends, is nearly as follows, in lbs. avoirdupois.

Names of Bodies.	*Sq. Bar.*	*One-third.*	*Rnd. Bar.*	*One-third.*
Oak	800	267	628	209
Ash	1137	379	893	298
Elm	569	189	447	149
Pitch pine	916	305	719	239
Deal	566	188	444	148
Cast iron	2580	860	2026	675
Wrought iron	4013	1338	3152	1050

PROBLEM I.

To find the ultimate transverse strength of any rectangular beam, supported at both ends, and loaded in the middle; or supported in the middle, and loaded at both ends; also, when the weight is between the middle and the end; likewise, when fixed at one end and loaded at the other.

RULE.—Multiply the strength of an inch square bar, 1 foot long, (as in the table,) by the breadth, and square of the depth in inches, and divide the product by the length in feet; the quotient will be the weight in lbs. avoirdupois.

EXAMPLE 1.—What weight will break a beam of oak 4 inches broad, 8 inches deep, and 20 feet between the supports?

$$\frac{800 \times 4 \times 8^2}{20} = 10240 \text{ lbs.}$$

NOTE.—When a beam is supported in the middle and loaded at each end, it will bear the same weight as when supported at both ends and loaded in the middle, that is, each end will bear half the weight.

When the weight is not situated in the middle of the beam, but placed somewhere between the middle and the end,—Multiply twice the length of the long end by twice the length of the short end, and divide the product by the whole length of the beam: the quotient will be the effectual length.

EXAMPLE 2.—Required the ultimate transverse strength of a pitch pine plank, 24 feet long, 3 inches broad, 7 inches deep; and the weight placed 8 feet from one end.

$$\frac{32 \times 16}{24} = 21.3 \text{ effective length.}$$

and

$$\frac{916 \times 3 \times 7^2}{21.3} = 6321 \text{ lbs.}$$

Again, when a beam is fixed at one end and loaded at the other, it will only bear $\frac{1}{4}$ of the weight as when supported at both ends and loaded in the middle.

EXAMPLE 3.—What is the weight requisite to break a deal beam 6 inches broad, 9 inches deep, and projecting 12 feet from the wall?

$$\frac{566 \times 6 \times 9^2}{12} = 22923 \div 4 = 5730.7 \text{ lbs.}$$

The same rules apply as well to beams of a cylindrical form, with this exception, that the strength of a round bar (as in the table) is multiplied by the cube of the diameter, in place of the breadth, and square of the depth.

EXAMPLE 4.—Required the ultimate transverse strength of a solid cylinder of cast iron, 12 feet long, and 5 inches diameter.

$$\frac{2026 \times 5^3}{12} = 21104 \text{ lbs.}$$

EXAMPLE 5.—What is the ultimate transverse strength of a hollow shaft of cast iron, 12 feet long, 8 inches diameter outside, and containing the same cross sectional area as a solid cylinder 5 inches diameter?

$$\sqrt{8^3 - 5^3} = 6.24, \text{ and } 8^3 - 6.24^3 = 269.$$

$$\text{Then, } \frac{2026 \times 269}{12} = 45418 \text{ lbs.}$$

NOTE.—When a beam is fixed at both ends, and loaded in the middle, it will bear one-half more than it will when free at both ends.

And if a beam is fixed at both ends, and the weight laid uniformly along its length, it will bear double; but if fixed at both ends, and the weight laid uniformly along its length, it will bear triple the weight.

PROBLEM X.

To find the breadth or depth of beams intended to support a permanent weight.

RULE.—Multiply the length between the supports, in feet, by the weight to be supported, in lbs., and divide the product by one-third of the ultimate strength of an inch bar, (as in the table,) multiplied by the square of the depth: the quotient will be the breadth, or, multiplied by the breadth, the quotient will be the square of the depth, both in inches.

EXAMPLE 1.—Required the breadth of a cast iron beam, 16 feet long, 7 inches deep, and to support a weight of 4 tons in the middle.

$$4 \text{ tons} = 8960 \text{ lbs. and}$$

$$\frac{8960 \times 16}{600 \times 7^2} = 3.4 \text{ inches.}$$

EXAMPLE 2.—What must be the depth of a cast-iron beam 3.4 inches broad, 16 feet long, and to bear a permanent weight of four tons in the middle?

$$\sqrt{\frac{8960 \times 16}{860 \times 3.4}} = 7 \text{ inches.}$$

NOTE 1.—When a beam is fixed at both ends, the divisor must be multiplied by 1.5, on account of it being capable of bearing one-half more.

2.—When a beam is loaded uniformly throughout, and loose at both ends, the divisor must be multiplied by 2, because it will bear double the weight.

3.—If a beam is fast at both ends, and loaded uniformly throughout, the divisor must be multiplied by 3, on account that it will bear triple the weight.

EXAMPLE 3.—Required the breadth of an oak beam, 20 feet long, 12 inches deep, made fast at both ends, and to be capable of supporting a weight of 12 tons in the middle.

12 tons = 26880 lbs. and

$$\frac{26880 \times 20}{266 \times 12^2 \times 1.5} = 9.7 \text{ inches.}$$

Again, when a beam is fixed at one end, and loaded at the other, the divisor must be multiplied by .25; because it will only bear one-fourth of the weight,

EXAMPLE 4.—Required the depth of a beam of ash, 6 inches broad, 9 feet projecting from the wall, and to carry a weight of 47 cwt.

47 cwt. = 5264 lbs. and

$$\frac{5264 \times 9}{\sqrt{379 \times 6 \times .25}} = 9.12 \text{ inches deep.}$$

And when the weight is not placed in the middle of a beam, the effective length must be found as in Problem I.

EXAMPLE 5.—Required the depth of a deal beam

20 feet long, and to support a weight of 63 cwt. 6 feet from one end.

$$\frac{28 \times 12}{20} = 16.8 \text{ effective length of beam, and}$$

$$63 \text{ cwt.} = 7056 \text{ lbs. hence}$$

$$\sqrt{\frac{7056 \times 16.8}{188 \times 6}} = 10.24 \text{ inches deep.}$$

Beams or shafts exposed to lateral pressure are subject to all the foregoing rules, but in the case of water-wheel shafts, &c., some allowances must be made for wear, then the divisor may be changed from 675 to 600 for cast iron.

EXAMPLE 6.—Required the diameter of bearings for a water-wheel shaft 12 feet long, to carry a weight of 10 tons in the middle.

$$10 \text{ tons} = 22400 \text{ lbs., and}$$

$$\frac{22400}{600} = \sqrt[3]{448} = 7.65 \text{ inches diameter.}$$

And when the weight is equally distributed along its length, the cube root of half the quotient will be the diameter, thus :

$$\frac{448}{2} = \sqrt[3]{224} = 6.07 \text{ inches diameter.}$$

EXAMPLE 7.—Required the diameter of a solid cylinder of cast iron, for the shaft of a crane, to be capable of sustaining a weight of 10 tons; one end of the shaft to be made fast in the ground, the other to project $6\frac{1}{2}$ feet; and the effective leverage of the jib as $1\frac{3}{4}$ to 1.

$$10 \text{ tons} = 22400 \text{ lbs., and}$$

$$\frac{22400 \times 6.5 \times 1.75}{675 \times .25} = 1509$$

And $\sqrt[3]{1509} = 11.47$ inches diameter.

The strength of cast iron to wrought iron, in this direction, is as 9 is to 14 nearly; hence, if wrought iron is taken in place of cast iron in the last example, what must be its diameter?

$$\sqrt[3]{\frac{1509 \times 9}{14}} = 9.89 \text{ inches diameter.}$$

ON TORSION OR TWISTING.

The strength of bodies to resist *torsion*, or wrenching asunder, is directly as the cubes of their diameters; or, if square, as the cube of one side; and inversely as the force applied multiplied into the length of the lever.

Hence the rule.—1. Multiply the strength of an inch bar, by experiment, (*as in the following table,*) by the cube of the diameter, or of one side in inches; and divide by the radius of the wheel, or length of the lever also in inches; and the quotient will be the ultimate strength of the shaft or bar, in lbs. avoirdupois.

2.—Multiply the force applied in pounds by the length of the lever in inches, and divide the product by one-third of the ultimate strength of an inch bar, (*as in the table,*) and the cube root of the quotient will be the diameter, or side of a square bar in inches; that is, capable of resisting that force permanently.

The following Table contains the result of experiments on inch bars, of various metals, in lbs. avoirdupois.

Names of Bodies.	*Rd. Bar.*	1 *third.*	*Sq. Bar.*	1 *third.*
Cast iron.....	11943	3981	15206	5069
English wrt. iron.	12063	4021	15360	5120
Swedish do. do....	11400	3800	14592	4864
Blistered steel ...	20025	6675	25497	8499
Shear do.	20508	6836	26112	8704
Cast do.	21111	7037	26880	8960
Yellow brass...	5549	1850	7065	2355
Cast copper	4825	1608	6144	2048
Tin.....	1688	563	2150	717
Lead	1206	402	1536	512

EXAMPLE 1.—What weight, applied on the end of a 5 feet lever, will wrench asunder a 3 inch round bar of cast iron?

$$\frac{11943 \times 3^3}{60} = 5374 \text{ lbs. avoirdupois.}$$

EXAMPLE 2.—Required the side of a square bar of wrought iron, capable of resisting the twist of 600 lbs. on the end of a lever 8 feet long.

$$\sqrt[3]{\frac{600 \times 96}{5120}} = 2\tfrac{1}{4} \text{ inches.}$$

In the case of revolving shafts for machinery, &c., the strength is directly as the cubes of their diameters, and revolutions, and inversely as the resistance they have to overcome; hence,

From *practice*, we find that a 40-horse power steam-engine, making 25 revolutions per minute, requires a shaft (*if made of wrought iron*) to be 8 inches diameter: now the cube of 8, multiplied by 25, and divided by 40 = 320; which serves as a constant multiplier for all others in the same proportion.

EXAMPLE 3.—What must be the diameter of a wrought iron shaft for an engine of 65-horse power, making 23 revolutions per minute?

$$\sqrt[3]{\frac{65 \times 320}{23}} = 9.67 \text{ inches diameter.}$$

Mr. Robertson Buchanan, in his Essay on Shafts, gives 400 as a constant multiplier for cast iron shafts that are intended for first movers in machinery;

200 for second movers; and

100 for shafts connecting smaller machinery, &c.

EXAMPLE 1.—The velocity of a 30-horse power steam-engine is intended to be 19 revolutions per

minute. Required the diameter of bearings for the fly wheel shaft.

$$\sqrt{\frac{400 \times 30}{13}} = 3.379 \text{ inches diameter.}$$

EXAMPLE 2.—Required the diameter of the bearings of shafts, as second movers from a 30-horse engine; their velocity being 30 revolutions per minute.

$$\sqrt{\frac{200 \times 30}{30}} = 3.3 \text{ inches diameter.}$$

NOTE.—When shafting is intended to be of wrought iron, use 60 as the multiplier for second movers; and 30 for shafts connecting smaller machinery.

TABLE

Of the proportionate length of bearings, or journals for shafts of various diameters.

Dia. in Inches.	Len. in Inches.	Dia. in Inches.	Len. in Inches.
1	1¼	6½	9¾
1¼	2½	7	9¾
2	3	7½	10
2½	3½	8	10¾
2¾	3¾	8½	11¾
3	4½	9	12
3½	4¾	9½	12¾
4	5¼	10	13¼
4½	6¼	10½	14
5	6¾	11	14¼
5½	7¼	11½	15¼
6	8¼	12	16

OF THE MECHANICAL POWERS.

When power is applied to overcome weight, or force to overcome resistance, the machines employed are called mechanic powers; and the application of such, the science of mechanics.

The power and weight are said to balance each other, or to be in equilibrio, when the effort of the one to produce motion in one direction is equal to the effort of the other to produce it in an opposite direction; or when the weight opposes that degree of resistance which is precisely required to destroy the action of the power.

The momentum or quantity of force of any moving body is the result of the quantity of matter multiplied by the velocity by which it is moved; and when the product arising from the multiplication of the particular quantities of matter in any two bodies by their respective velocities are equal, their momentum will be so too.

And it holds universally true, that when two bodies are suspended upon any machine, so as to act contrary to each other, if the machine be put in motion, and the perpendicular ascent of one body, multiplied into its weight, be equal to the perpendicular descent of the other, multiplied into its weight, those bodies, however unequal they may be in weight, will balance each other in all situations; for as the whole ascent of the one is performed in the same time as the whole descent of the other, their respective velocities must be as the spaces they move through; and the excess of weight in the one is compensated by the excess of velocity in the other. Upon this principle it is easy to compute the power of any machine, either simple or compound; for it is only finding how much swifter the power moves than the weight; and just so much is the power increased by the help of the machine.

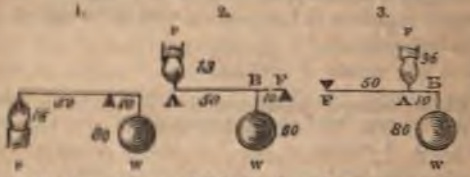
The simple machines, usually called mechanic powers, are six in number, namely, the Lever, the Wheel and Axle, the Pulley, the Inclined Plane, the Wedge, and the Screw.

There are three kinds of levers, caused by the different situations of the weights, props, and powers.

1.—When the weight is at one end, the power at the other, and the prop somewhere between.

2.—When the prop is at one end, the power at the other, and the weight between. And,

3.—When the prop is at one end, the weight at the other, and the power between. Thus,



In the first and second kind, the advantage gained is as the distance of the power from the prop, to the distance of the weight from the prop.

In the third kind, that there may be a balance between the power and the weight, the intensity of the power must exceed the intensity of the weight, just as much as the distance of the weight from the prop exceeds the distance of the power from the prop, that is, $P \times A F = W \times B F$; or the power and weight are reciprocally as the distances at which they act.

Or, in other words, Multiply the weight given by the distance from the prop, and divide by the distance from the power; the quotient will be the power or weight required.

Examples 1, 2, and 3.

Required the power necessary to counterpoise a weight of 80 lbs. on each of the three levers, whose lengths

are 60 inches, and in the first and second 10 inches from weight to prop, the third being 10 inches from weight to power.

$$\text{First}\ldots\ldots\frac{80 \times 10}{50} = 16 \text{ lbs. power.}$$

$$\text{Second}\ldots\frac{80 \times 10}{60} = 13.33 \text{ lbs. power.}$$

$$\text{Third}\ldots\ldots\frac{80 \times 60}{50} = 96 \text{ lbs. power.}$$

EXAMPLE 4.—What power is necessary to raise a weight of 620 lbs. by a lever of the first order, 72 inches long, and the prop placed 12 inches from the weight?

$$72 - 12 = 60 \text{ inches to power.}$$

$$\text{Then } \frac{620 \times 12}{60} = 124 \text{ lbs.}$$

EXAMPLE 5.—A weight of 620 lbs. is to be lifted by a power of 124 lbs. applied to the end of a lever of the first order, 72 inches long; required at what distance from the weight the prop must be placed.

$$\frac{124 \times 72}{620 + 124} = 12 \text{ inches.}$$

EXAMPLE 6.—A beam 20 feet long, and supported at both ends, bears a weight of 73 cwt. 4 feet 6 inches from one end; required the proportion of weight upon each support.

$$\frac{73 \times 4.5}{20} = 16.425 \text{ cwt. on the furthest support.}$$

$$\text{And } \frac{73 \times 15.5}{20} = 56.675 \text{ cwt. on the nearest support.}$$

EXAMPLE 7.—A weight of 300 lbs. is fixed on the end of a lever 6 feet long; required the power, applied $2\frac{1}{2}$ feet from the prop, to raise the weight.

$$\frac{300 \times 6}{2.5} = 720 \text{ lbs. power.}$$

WHEEL AND AXLE.

Here the velocity of the power is to the velocity of the weight as the circumference of the wheel is to the circumference of the axle; hence, Divide the velocity of the power by the velocity of the weight, and the quotient is the weight that the power is equal to.

EXAMPLE 1.—A power equal to 30 lbs. is applied to the winch of a crane whose length is 15 inches; the pinion contains 10 teeth, the wheel 120, and the barrel is 9 inches diameter; required the weight raised.

$15 \times 2 \times 3.1416 = 94.248$ circumference of the circle described by the winch, or handle, $120 \div 10 = 12$ revolutions of the pinion for one of the wheel, and $3.1416 \times 9 = 28.2744$ the barrel's circumference; then,

$$\frac{94.248 \times 12 \times 30}{28.2744} = 1200 \text{ lbs. raised by this crane.}$$

EXAMPLE 2.—What would be the increase of power, in the last example, if a wheel of 150 teeth, and a pinion of 15, were added to the crane?

$150 \div 15 = 10$, that is, the velocity of the weight is diminished, while the velocity of the power is the same; then,

$$\frac{94.248 \times 12 \times 10 \times 30}{28.2744} = 12000 \text{ lbs. raised,}$$

the power being increased ten times.

EXAMPLE 3.—What power is requisite to raise 42 tons 60 feet high in 10 minutes, the velocity of the power being twenty feet per minute?

$60 \div 10 = 6$, and $\frac{\sqrt{42} \times 6}{20} = 12.6$ tons power.

TO CALCULATE FOR THE DIFFERENT PARTS OF A CRANE, AS RESPECTS MECHANICAL ADVANTAGE.

1. *The number of revolutions of the pinion to one of the wheel, the length of the handle, and the force applied given, to find the diameter of the barrel.*

RULE.—Multiply the diameter of the circle described by the winch, or handle, in inches, by the power applied in lbs., and by the number of revolutions of the pinion to one of the wheel; divide the product by the weight to be raised in lbs., and the quotient is the barrel's diameter in inches.

EXAMPLE.—Suppose that two men were required to raise a weight of one ton, by a crane, and each man to exert a constant force of $33\frac{1}{2}$ lbs. on a handle 16 inches long, the pinion making seven revolutions for one of the wheel, what must be the barrel's diameter?

$16 \times 2 = 32$ inches, diameter of the circle described by the handle, and $33\frac{1}{2} \times 2 = 67$ lbs. constant force; then,

$$\frac{32 \times 67 \times 7}{2240} = 6.7 \text{ inches.}$$

2.—*The diameter of the barrel, the length of the handle, and force applied given, to find the number of revolutions of the pinion to one of the wheel.*

RULE.—Multiply the weight to be raised in lbs. by the diameter of the barrel in inches, and divide the product by the diameter of the circle described by the handle in inches, multiplied by the power applied in lbs., and the quotient is the revolutions of the pinion to one of the wheel.

EXAMPLE.—What must be the number of revolutions of the pinion to one of the wheel, when the power applied is 67 lbs., the length of the handle 16 inches,

and the barrel 6.7 inches diameter, to counterpoise a weight of one ton, or 2240 lbs. ?

$$\frac{2240 \times 6.7}{32 \times 67} = 7 \text{ revolutions to one of the wheel.}$$

3.—*The diameter of the barrel, the number of revolutions of the pinion to one of the wheel, and the power applied given, to find the length of the handles.*

RULE.—Multiply the weight to be raised in lbs. by the barrel's diameter in inches, and divide the product by the power applied in lbs., multiplied by the number of revolutions of the pinion to one of the wheel, and half the quotient is the length of the handles.

EXAMPLE.—It is estimated that the united effort of two men at the handles of a crane is 67 lbs. nearly; now a crane having a barrel of 6.7 inches diameter, and a pinion 7 to 1 of the wheel, what must be the length of handles to raise a weight of 1 ton ?

$$\frac{2240 \times 6.7}{67 \times 7} = \frac{32}{2} = 16 \text{ inches.}$$

4.—*The diameter of the barrel, the revolutions of the pinion to one of the wheel, and length of handles given, to find the power required.*

RULE.—Multiply the weight to be raised in lbs. by the diameter of the barrel in inches, and divide the product by the diameter of the circle described by the handle, multiplied by the revolutions of the pinion to one of the wheel, and the quotient is the power required.

EXAMPLE.—What power will be required to raise one ton by a crane, whose barrel is 6.7 inches diameter, the pinion 7 to 1 of the wheel, and each handle 16 inches long ?

$$\frac{2240 \times 6.7}{32 \times 7} = 67 \text{ lbs. power.}$$

NOTE.—The handles of a crane ought not to be less than 2 feet 11 inches, or 3 feet from the ground, and the jib to angle of about 45 degrees.

To find the thickness of cast iron for a crane post, when fixed at one end, and loaded at the other.

RULE.—Multiply the weight that the crane is to lift in lbs. by the leverage of the jib to one of the post, and by the length of the post in feet; divide the product by 168, then subtract the quotient from the cube of the outside diameter, and the cube root of the difference is the inside diameter.

EXAMPLE.—What thickness must the metal be for a crane post to carry a weight of ten tons, the diameter of the post being 16 inches, and projecting 6 feet from the ground, the leverage of the jib being as $3\frac{1}{2}$ to 1 of the post?

10 tons = 22400 lbs.; then,

$$\frac{22400 \times 3.5 \times 6}{168} = 2800$$

the cube of 16 = 4096, and

$$4096 - 2800 = \sqrt[3]{1296} = 10.9$$

$$16 - 10.9 = \frac{5.1}{2} = 2\tfrac{1}{2} \text{ inches in thickness.}$$

THE PULLEY.

A single pulley, that only turns on its axis, and does not move out of its place, serves only to change the direction of the power, but gives no mechanical advantage. The advantage gained is always as twice the number of moveable pulleys, without taking any notice of the fixed pulleys necessary to compose the system of pulleys; hence, Divide the weight to be raised by twice the number of moveable pulleys, and the quotient is the power required to raise the weight, in terms of the same name.

EXAMPLE 1.—What power is requisite to raise 250 lbs. with a pair of four-shieved blocks, the one block moveable and the other fixed?

$4 \times 2 = 8$, and $\frac{250}{8} = 31.25$ lbs. power.

EXAMPLE 2.—What weight will a power of 120 lbs. raise, when applied to a three and four-shieved block, the three being moveable and the other fixed?

$3 \times 2 = 6$, and $120 \times 6 = 720$ lbs. raised.

THE INCLINED PLANE.

The advantage gained by the inclined plane is as great as its length exceeds its perpendicular height; hence, when the power acts parallel to the plane, the length of the plane is to the weight as the height of the plane is to the power,—or, in other words, multiply the weight by the perpendicular height of the plane, and divide by its length, the quotient is the power that will support that weight upon the plane.

EXAMPLE 1.—Required the power, or equivalent weight, capable of supporting a load of 300 lbs. upou an inclined plane 50 feet long and 16 feet high.

50 is to 16 as 300 is to 96,

Or, $\frac{300 \times 16}{50} = 96$ lbs. power.

EXAMPLE 2.—A power of 120 lbs., with a velocity of 50 feet per minute, is to be applied to move a weight up an inclined plane at the rate of 30 feet per minute; the plane is 25 feet long and 8 feet high; required the weight that the power is equal to.

$120 \times 50 = 6000$, and $30 \times 8 = 240$; then,

As $240 : 25 :: 6000 : 625$ lbs.

The weight multiplied by the length of the base, and divided by the length of the plane, equal the pressure on the plane.

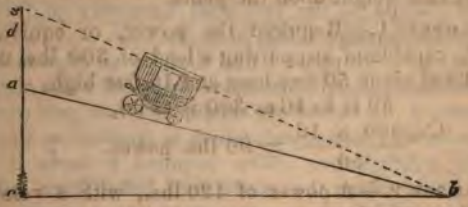
The space which a body describes upon an inclined plane, when descending by the force of gravity, is to the space which it would fall freely in the same time,

as the height is to the length of the plane, and the spaces being the same, the times will be inversely in this proportion.

Again, if two bodies descend from rest down two planes, equally inclined to the horizon, and then, without any loss of velocity, proceed to descend down two other inclined planes, also equally inclined to the horizon, the lengths of which are to each other in the same proportion as the lengths of the first two planes, the squares of the times of their whole motion will be in the same proportion as the lengths of the planes.

Means of ascertaining practically the effect produced by inclined planes.

Provide a board or box, *a b*, capable of holding pebbles, sand, &c., and which by a screw, *c*, can be easily raised at one end, as *a d s*, &c.



When *a b* lies flat on *c b*, the carriage will be at rest; but by the screw at *c* raising *a b* leisurely, the carriage will, at a certain height, set off by itself, and run down the plane. Then are we in possession of a triangle that solves what force is necessary to drag any load of any kind on a road or level ground; for the hypotenuse *a b* represents the weight of the carriage, and the perpendicular *a c* what portion of that weight is necessary to draw the carriage on level ground, thus,

Suppose the carriage .... 12 cwt.
The line *a b*..... 24 feet.
Height *c a* ..... 3 feet.

The declivity, then, is as 3 to 24, or $\frac{1}{8}$. In this case it will be found that $\frac{1}{8}$ of the weight of the carriage would drag it on such a road or level ground, namely, $1\frac{1}{2}$ cwt.; but if the road were very deep and rough, it might require to be raised perhaps as high as *d* or *s*, before the carriage would set off. Now, if *c s* were half the length of *s b*, then it would require one-half the weight of the carriage to drag it on level ground, or, in the above case, 6 cwt.

This rule is universal, and has been proved by carriages at large, on roads of every description.

In estimating the draft up hill, the draft on the level must be added to it. Suppose the hill rises 1 foot in 4, then $\frac{1}{4}$ part of the weight must be added to the draft on level ground.

If the weight be, as before, 12 cwt., then $\frac{1}{4}$ would be 3 cwt.; and if its draft on a level were $1\frac{1}{2}$ cwt., then $4\frac{1}{2}$ cwt. would be the real draft necessary to draw 12 cwt. up a hill rising 1 foot in 4, &c.

EXAMPLE.—Suppose I find that, on an edge railway, a loaded carriage will just move by itself when there is a descent of $3\frac{1}{2}$ inches per chain, or about one perpendicular for 224 horizontal, which is (reckoning the carriage to weigh 1 ton) 10lbs. required to move it on a level. Now, from the above data, what force will be required to drag the same weight up a similar road ascending 1 inch per yard, or $\frac{1}{36}$? $\frac{1}{36}$ of a ton is $62\frac{8}{10}$ lbs., which added to 10 lbs. as above, amounts to $72\frac{8}{10}$ lbs., the weight required to drag it up an ascent of $\frac{1}{36}$; and allowing the strength of an ordinary horse to be 140 lbs., he will only be able to drag $1\frac{9}{10}$, or say 2 tons up an ascending plane of 1 in 36.

THE WEDGE.

As the wedge is seldom used without being driven, the force of the blow is not easily ascertained; of course, in practice it is not worth taking into account with respect to calculation.

THE SCREW.

The advantage gained by the screw is as much as the circumference of a circle, described by the lever or handle, exceeds the interval or distance between the spirals of the screw; hence, as the circumference of the circle described by the handle is to the pitch of the screw, so is the weight to the power.

EXAMPLE.—What power is necessary to raise a weight of 6000 lbs., the length of the lever being 20 inches, and the screw $\frac{3}{4}$ pitch?

$20 \times 2 = 40 \times 3.1416 = 125.6$ inches; then,
As 125.6 : .75 :: 6000 : 35.8 lbs., power required.

N.B.—There are few machines but what, on account of the friction of the parts against one another, will require a third part more power to work them, when loaded, than is requisite to constitute a balance between power and weight.

The following Table shows the estimated power of man or horse as applied to machinery.

Application of the power.	Lbs. Avr. at the rate of 220 feet ℘ minute.	Lbs. Avr. at the rate of one foot ℘ minute.
A man is supposed to be capable of lifting or carrying	27.273 or	6000
A man is supposed to be capable of turning the winch of a crane with a force equal to	28.637 or	6300
When the united efforts of two men are applied to the winch of a crane, the handles being at right angles, each man exerts a force equal to.....	33.499 or	7350
A man is supposed to exert a power in pumping equal to	17.335 or	3814
In ringing, a man exerts a force equal to.....	33.955 or	8570
And in rowing	40 955 or	9010
The power of a horse equal to.....	150 or	33000

OF FALLING BODIES.

In bodies falling freely by their own weight, their velocities are as the times, and the spaces as the square of the times; therefore, if the times be as the numbers .....1, 2, 3, 4, &c.
The velocities will be also .....1, 2, 3, 4, &c.
The spaces passed through .....1, 4, 9, 16, &c.
And the spaces for each time, as the odd numbers .....1, 3, 5, 7, &c.

It has been ascertained by experiment that a body falling freely from rest will descend through $16\frac{1}{12}$ feet in the first second of time, and will then have acquired a velocity which, being continued uniformly, will carry it through $32\frac{2}{12}$ feet in the next second, consequently, if the first series of numbers be expressed in seconds,

	1″	2″	3″
Velocities in feet will be	$32\frac{2}{12}$	$64\frac{4}{12}$	$96\frac{1}{2}$, &c.
Spaces in the whole times.....	$16\frac{1}{12}$	$64\frac{4}{12}$	$144\frac{3}{4}$, &c.
And the spaces for each second..	$16\frac{1}{12}$	$48\frac{1}{4}$	$80\frac{5}{12}$, &c.

To find the velocity a falling body will acquire in any given time.

RULE.—Multiply the time in seconds by 32.166, and the product will be the velocity acquired in feet per second.

EXAMPLE.—Required the velocity in 7 seconds.

$32.166 \times 7 = 225.162$ feet, velocity acquired.

To find the velocity a body will acquire by falling from any given height.

RULE.—Multiply the space in feet by 64.33, and the square root of the product will be the velocity acquired in feet per second.

EXAMPLE.—Required the velocity a ball will acquire in descending through 201 feet.

$$\sqrt{64.33} \times 201 = 113.7 \text{ feet.}$$

To find the space through which a body will fall in any given time.

RULE.—Multiply the square of the time in seconds by 16.083, and the product will be the space in feet.

EXAMPLE.—Required the space fallen through in 7 seconds.

$$16.083 \times 49 = 788.067 \text{ feet.}$$

NOTE.—The velocity acquired by a body in falling from rest, through a given height, is the same whether it fall freely or descend through a plane any way inclined.

The diameter of a circle perpendicular to the horizon, and any chord terminating at either extremity of that diameter, are fallen through in the same time.

And the velocities which bodies acquire by descending along chords of the same circle are as the lengths of those chords.

TABLE

Of accelerated motion of falling bodies.

Time in seconds of the body's fall.	Space fallen through during each second in feet.	Whole space fallen through in feet.	Velocity acquired at the end of the time.
1	16.095	16.095	32.19
2	48.285	64.380	64.38
3	80.475	144.855	96.57
4	112.665	257.520	128.76
5	144.855	402.375	160.95
6	177.045	579.420	193.14
7	209.235	788.655	225.33
8	241.425	1030.080	257.52
9	273.615	1303.695	289.71
10	305.805	1609.495	321.90

ON PENDULUMS.

A pendulum that vibrates seconds, or 60 in the latitude of London, is 39.1393 inches long; and $\sqrt{39.1393} \times 60 = 375.36$, which serves as a constant number for other pendulums; thus, 375.36, divided by the square root of the pendulum's length, gives the number of vibrations per minute; and divided by the vibrations per minute, gives the square root of the length of pendulums.

EXAMPLE 1.—Required the number of vibrations a pendulum of 25 inches long will make per minute.

$$\frac{375.36}{\sqrt{25}} = 75.072 \text{ vibrations per minute.}$$

EXAMPLE 2.—Required the length of a pendulum to make 80 vibrations per minute.

$$\frac{375.36}{80} = 4.692^2 = 22.014864 \text{ inches long.}$$

Table containing the length of pendulums to vibrate seconds in various parts of the world.

At Sierra Leone	39.01954 in.	At New York	39.10153 in.
" Trinidad	39.01879 "	" Bordeaux	39.11282 "
" Madras	39.02630 "	" Paris	39.12843 "
" Jamaica	39.03508 "	" Edinburgh	39.15540 "
" Rio Janeiro	39.01206 "	" Greenland	39.20328 "

A pendulum vibrating half seconds in the latitude of London is 9.8 inches in length; and for quarter seconds 2.5 inches.

ON THE VELOCITY OF WHEELS, DRUMS, PULLEYS, &c.

When wheels are applied to communicate motion from one part of a machine to another, their teeth act alternately on each other; consequently, if one wheel contains 60 teeth and another 20, the one containing 20 teeth will make three revolutions, while the other makes but one; and if drums or pulleys are taken in place of wheels, the result will be the same; because their circumferences, describing equal spaces, render their revolutions unequal: from this the rule is derived, namely,

Multiply the velocity of the driver by the number of teeth it contains, and divide by the velocity of the driven; the quotient will be the number of teeth it ought to contain. Or, Multiply the velocity of the driver by its diameter, and divide by the velocity of the driven; the quotient will be the diameter of the driven.

EXAMPLE 1.—If a wheel that contains 75 teeth makes 16 revolutions per minute, required the number of teeth in another to work in it, and make 24 revolutions in the same time

$$\frac{75 \times 16}{24} = 50 \text{ teeth.}$$

EXAMPLE 2.—A wheel, 64 inches diameter, and making 42 revolutions per minute, is to give motion to a shaft at the rate of 77 revolutions in the same time: required the diameter of a wheel suitable for that purpose.

$$\frac{64 \times 42}{77} = 34.9 \text{ inches.}$$

[illegible] the number of revolutions [illegible] pulley 20 inches diame[illegible] 4 feet diameter, and [illegible] minute.

[illegible] = 40.= revolutions.

[illegible] the rate of 22 revolutions [illegible] by a pair of wheels, to [illegible] the distance of the [illegible] inches; the diameters [illegible] required.

[illegible] 18.81 inches = the driving wheel.

[illegible] 10.34 inches = the driven wheel.

[illegible] Suppose a drum to make 20 revolutions per minute, and [illegible] diameter of another to make 38 revolutions in the same time.

[illegible] their diameters must be [illegible] the one making 20 revolutions [illegible] inches, the other will be [illegible] inches diameter.

EXAMPLE 6.—Required the diameter of a pulley, to make 12½ revolutions in the same time as one of 32 inches making 26.

$$\frac{32 \times 26}{12.5} = 66.56 \text{ inches diameter.}$$

EXAMPLE 7.—A shaft, at the rate of 16 revolutions per minute, is to give motion to a piece of machinery at the rate of 81 revolutions in the same time; the motion is to be communicated by means of two wheels and two

pulleys with an intermediate shaft; the driving wheel contains 54 feet, and the driving pulley is 25 inches diameter; required the number of teeth in the other wheel, and the diameter of the other pulley.

$\sqrt{81 \times 16} = 36$, the mean velocity between 16 and 81; then, $\frac{16 \times 54}{36} = 24$ teeth; and $\frac{36 \times 25}{81} = 11.11$ inches, diameter of pulley.

EXAMPLE 8.—Suppose in the last example the revolutions of one of the wheels to be given, the number of teeth in both, and likewise the diameter of each pulley, to find the revolutions of the last pulley.

$\frac{16 \times 54}{24} = 36$, velocity of the intermediate shaft;

and $\frac{36 \times 25}{11.11} = 81$, the velocity of the machine.

TABLE

*... ... ...

RULE.—Multiply the radius in the table by the pitch given, and the product will be the radius of the wheel required.

Or, Divide the radius of the wheel by the radius in the table, and the quotient will be the pitch of the wheel required.

EXAMPLE 1.—Required the radius of a wheel to contain 64 teeth, of 3 inch pitch.

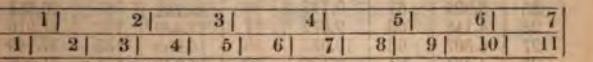
$$10.19 \times 3 = 30.57 \text{ inches.}$$

EXAMPLE 2.—What is the pitch of a wheel to contain 80 teeth, when the radius is 25.47 inches?

$$25.47 \div 12.735 = 2 \text{ inch pitch.}$$

Or, set off upon a straight line seven times the pitch given, divide that, or another exactly the same length, into eleven equal parts; call each of those divisions four, or each of those divisions will be equal to four teeth upon the radius.

EXAMPLE.—Were it required to find the diameter of a wheel to contain 21 teeth, the construction would be as follows:—



Thus, 5 divisions and $\frac{1}{4}$ of another equal the radius of the wheel.

Regular approved proportions for wheels with flat arms in the middle of the ring, and ribs, or feathers, on each side.

The length of the teeth = $\frac{6}{9}$ the pitch, besides clearance, or $\frac{5}{7}$ the pitch, clearance included.

Thickness of the teeth	$\frac{4}{9}$ the pitch.
Breadth on the face	$2\frac{1}{2}$ "
Edge of the rim	$\frac{4}{9}$ "
Rib projecting inside the rim	$\frac{4}{9}$ "
Thickness of the flat arms	$\frac{4}{9}$

Breadth of the arms at the points = 2 teeth and $\frac{1}{4}$ the pitch, getting broader towards the centre of the wheel in the proportion of $\frac{1}{2}$ inch to every foot in length.

Thickness of the ribs, or feathers, $\frac{1}{4}$ the pitch.

Thickness of metal round the eye, or centre, $\frac{1}{3}$ the pitch.

Wheels made with plain arms, the teeth are in the same proportion as above; the ring and the arms are each equal to one cog or tooth in thickness, and the metal round the eye same as above, in feathered wheels.

To find the power that a cast iron wheel is capable of transmitting at any given velocity.

RULE.—Multiply the breadth of the teeth, or face of the wheel in inches, by the square of the thickness of one tooth, and divide the product by the length of the teeth, the quotient is the strength in horses' power at a velocity of 136 feet per minute.

EXAMPLE.—Required the power that a wheel of the following dimensions ought to transmit with safety, namely,

Breadth of teeth.....$7\frac{1}{2}$ inches,
Thickness.....1.4
And length.....2

$1.4^2 = 1.96$, and $\frac{7.5. \times 1.96}{2} = 7.35$ horses' power.

The strength at any other velocity is found by multiplying the power so obtained by any other required velocity, and by .0044, the quotient is the power at that velocity.

Suppose the wheel as above, at a velocity of 320 feet per minute.

$7.35 \times 320 \times .0044 = 10.3488$ horses' power.

ON THE MAXIMUM VELOCITY AND POWER OF WATER WHEELS.

Since publishing the first edition of this work, I have endeavoured, as far as possible, to acquire the most improved practical principles of water wheels as a moving power; and

1.— *Of undershot wheels.*

The term undershot is applied to a wheel when the water strikes at, or below, the centre. And the greatest effect is produced when the periphery of the wheels moves with a velocity of .57 that of the water; —hence, to find the velocity of the water, multiply the square root of the perpendicular height of the fall in feet by 8, and the product is the velocity in feet per second.

EXAMPLE.—Required the maximum velocity of an undershot wheel, when propelled by a fall of water 6 feet in height.

$\sqrt{6} = 2.45 \times 8 = 19.6$ feet velocity of water.

And $19.6 \times .57 = 11.17$ feet per second for the wheel.

2.—*Of breast and overshot wheels.*

Wheels that have the water applied between the centre and the vertex are styled breast wheels, and overshot when the water is brought over the wheel and laid on the opposite side; however, in either case the maximum velocity is $\frac{2}{3}$ that of the water; hence, to find the head of water proper for a wheel at any velocity, say,

As the square of 16.083, or 258.67, is to 4, so is the

square of the velocity of the wheel in feet per second to the head* of water required.

EXAMPLE.—Required the head of water necessary for a wheel of 24 feet diameter, moving with a velocity of 5 feet per second.

$$\frac{5 \times 3}{2} = 7.5 \text{ feet velocity of the water.}$$

And $258.67 : 4 :: 7.5^2 : .87$ feet, head of water required.

But one-tenth of a foot of head must be added for every foot of increase in the diameter of the wheel, from 15 to 20 feet, and .05 more for every foot of increase from 20 to 30 feet, commencing with five-tenths for a 15 feet wheel.

This additional head is intended to compensate for the friction of water in the aperture of the sluice to keep the velocity as 3 to 2 of the wheel; thus, in place of .87 feet head for a 24 feet wheel, it will be $.87 + 1.2 = 2.07$ feet head of water.

If the water flow from under the sluice, multiply the square root of the depth in feet by 5.4, and by the area of the orifice also in feet, and the product is the quantity discharged in cubic feet per second.

Again, if the water flow over the sluice, multiply the square root of the depth in feet by 5.4; and $\frac{2}{3}$ of the product multiplied by the length and depth, also in feet, gives the number of cubic feet discharged per second nearly.

EXAMPLE 1.—Required the number of cubic feet per second that will issue from the orifice of a sluice 5 feet long, 9 inches wide, and 4 feet from the surface of the water.

$$\sqrt{4} = 2 \times 5.4 = 10.8 \text{ feet velocity,}$$

And $5 \times .75 \times 10.8 = 40.5$ cubic feet per second.

* By *head* is understood the distance between the aperture of the sluice and where the water strikes upon the wheel.

EXAMPLE 2.—What quantity of water per second will be expended over a wear, dam, or sluice, whose lengths is 10 feet, and depth 6 inches?

$$\sqrt{.5} = .2236 \times 5.4 = \frac{1.20744 \times 2}{3} = .80496$$

feet velocity; then, $10 \times .5 = 5$ feet, and $.80496 \times 5 = 4.0248$ cubic feet per second nearly.

In estimating the power of water wheels, half the head must be added to the whole fall, because 1 foot of fall is equal to 2 feet of head; call this the effective perpendicular descent; multiply the weight of the water per second by the effective perpendicular descent and by 60; divide the product by 33,000, and the quotient is the effect expressed in horses' power.

EXAMPLE 1.—Given 16 cubic feet of water per second, to be applied to an undershot wheel, the head being 12 feet, required the power produced.

$$12 \div 2 = 6 \text{ and } \frac{6 \times 16 \times 62.5 \times 60}{33000} = 10.9$$

horses' power nearly.

EXAMPLE 2.—Given 16 cubic feet of water per second, to be applied to a high breast or an overshot wheel, with 2 feet head and 10 feet fall; required the power.

$$2 \div 2 = 1 \text{ and } \frac{\overline{1 + 10} \times 16 \times 62.5 \times 60}{33000} = 20$$

horses' power.

N.B.—Only about two-thirds of the above results can be taken as real communicative power to machinery.

OF THE CIRCLE OF GYRATION IN WATER WHEELS.

The centre or circle of gyration is that point in a revolving body into which, if the whole quantity of matter were collected, the same moving force would generate the same angular velocity, which renders it of the utmost importance in the erection of water wheels, and the motion ought always to be communicated from that point when it is possible.

To find the circle of gyration.

RULE.—Add into one sum twice the weight of the shrouding, buckets, &c., multiplied by the square of the radius, $\frac{2}{3}$ of the weight of the arms, multiplied by the square of the radius, and the weight of the water multiplied by the square of the radius also; divide the sum by twice the weight of the shrouding, arms, &c., added to the weight of the water, and the square root of the quotient is the distance of the circle of gyration from the centre of suspension nearly.

EXAMPLE.—Required the distance of the centre of gyration from the centre of suspension in a water wheel 22 feet diameter, shrouding, buckets, &c., = 18 tons, arms . . 12 tons, and water = 10 tons.

	$22 \div 2 = 11$	and	$11^2 =$	121
Then,	$18 \times 2 = 36$	$\times$	121 =	4356
	$\frac{2}{3}$ of $12 = 8$	$\times$	121 =	968
	water $= 10$	$\times$	121 =	1210
				6534

And $18 + 12 \times 2 = 60 + 10 = 70$; hence,

$\sqrt{\frac{6534}{70}} = 9.6$ feet from the centre of suspension nearly.

Table of angles for windmill sails.

The radius is supposed to be divided into six equal parts, and $\frac{1}{6}$ from the centre is called 1, the extremity being denoted by 6.

No.	*Angle with the Plane of Motion.*	
1	18°	24°
2	19	21
3	18	18
4	16	14
5	$12\frac{1}{2}$	9
6	7	3 *extremity.*

The first column contains the angles according to Smeaton; but experience has taught us that the angles in the second column are preferable.

THE VELOCITY OF THRASHING MACHINES, MILLSTONES, BORING IRON, &c.

The drum or beaters of a thrashing machine ought to move with a velocity of about 3000 feet per minute; hence, divide 11460 by the diameter of the drum in inches; or 955 by the diameter of the drum in feet; and the quotient is the number of revolutions required per minute, And

The feeding rollers must make half the revolutions of the drum, when their diameters are about $3\frac{1}{2}$ inches.

If the machine is driven by horses, their velocity ought to be from $2\frac{1}{2}$ to 3 times round a 24 feet ring per minute.

Divide 500 by the diameter of a millstone, in feet, or 6000 by the diameter in inches, and the quotient is the number of revolutions required per minute.

In boring cast iron the cutters ought to have a velocity of about 108 inches per minute, or divide 36 by the diameter in inches, the quotient is the number of revolutions of the boring head per minute.

And divide 100 by the diam. in inches, the quotient is the number of revolutions per minute, for turning wrought iron in general, and about half that velocity for cast iron.

OF PUMPS AND PUMPING ENGINES.

Pumps are chiefly designated by the names of lifting and force pumps: lifting pumps are applied to wells, &c., where the height of the bucket, from the surface of the water, must not exceed 33 feet: this being nearly equal to the pressure of the atmosphere, or the height to which water would be forced up into a vacuum by the pressure of the atmosphere. Force pumps are applicable on all other occasions, as raising water to any required height, supplying boilers against the force of the steam, hydrostatic presses, &c.

The power required to raise water to any height is as the weight and velocity of the water with an addition of about $\frac{1}{5}$ of the whole power for friction; hence the rule,—Multiply the perpendicular height of the water, in feet, by the velocity, also in feet, and by the square of the pump's diameter in inches, and again by .341; (this being the weight of a column of water 1 inch diameter, and 12 inches high, in lbs. avoirdupois;) divide the product by 33,000, and $\frac{1}{5}$ of the quotient added to the whole quotient, will be the number of horses' power required.

EXAMPLE.—Required the power necessary to overcome the resistance and friction of a column of water 4 inches diameter, 60 feet high, and flowing with a velocity of 130 feet per minute.

$$\frac{60 \times 130 \times 4^2 \times .341}{33000} = \frac{1.3}{5} = .26 + 1.3 = 156$$

horses' power nearly.

NOTE.—Hot liquor pumps, or pumps to be employed in raising any fluid where steam is generated, require to be placed in the fluid, or as low as the bottom of it, on account of the steam filling the pipes, and acting as a counterpoise to the atmosphere; and the diameter of the pipes to and from a p ought not to be less than $\frac{3}{4}$ of the pump's diameter.

The diameter of a pump and velocity of the water given, to find the quantity discharged in gallons, or cubic feet, in any given time.

RULE.—Multiply the velocity of the water, in feet per minute, by the square of the pump's diameter in inches, and by .034 for imperial gallons; or, .0005454 for cubic feet, and the product will be the number of gallons, or cubic feet, discharged in the given time, nearly.

EXAMPLE.—What is the number of imperial gallons of water discharged per hour by a pump 4 inches diameter, the water flowing at the rate of 130 feet per minute?

$$130 \times 60 = 7800 \text{ feet per hour.}$$
$$\text{And, } 7800 \times 4^2 \times .034 = 4243.2 \text{ gallons.}$$

The length of stroke and number of strokes given, to find the diameter of a pump, and number of horses' power that will discharge a given quantity of water in a given time.

RULE 1.—Multiply the number of imperial gallons required, in the given time, by 353, or the number of cubic feet by 2201, and divide the product by the velocity of the water, in inches, and the square root of the quotient will be the pump's diameter, in inches.

2.—Multiply the number of gallons per minute by 10, or the number of cubic feet by 62.5, and by the perpendicular height of the water in feet, divide the product by 33,000, then will $\frac{1}{5}$ of the quotient, added to the whole quotient, be the number of horses' power required.

EXAMPLE.—Required the diameter of a pump, and number of horses' power, capable of filling a cistern 20 feet long, 12 feet wide, and $6\frac{1}{2}$ feet deep, in 45 minutes,

whose perpendicular height is 53 feet; the pump to have an effective stroke of 26 inches, and make 30 strokes per minute.

$20 \times 12 \times 6.5 = 1560$ cubic feet, and

$\frac{1560}{45} = 34.66$ cubic feet per minute.

Then, $\sqrt{\frac{34.66 \times 2201}{26 \times 30}} = 9.89$ inches diameter of pump.

And $\frac{34.66 \times 62.5 \times 53}{33000} = \frac{3.48}{5} = .69 + 3.48 = 4.17$ horses' power.

To find the time a cistern will take in filling, when a known quantity of water is going in, and a known portion of that water is going out, in a given time.

RULE.—Divide the content of the cistern, in gallons, by the difference of the quantity going in, and the quantity going out, and the quotient is the time in hours and parts that the cistern will take in filling.

EXAMPLE.—If 30 gallons per hour run in and 22½ gallons per hour run out of a cistern capable of containing 200 gallons, in what time will the cistern be filled?

$30 - 22.5 = 7.5$, and $200 \div 7.5 = 26.666$, or 26 hours and 40 minutes.

To find the time a vessel will take in emptying itself of water.

Mr. Banks ascertained, from very accurate experiments, that a vessel, 3.166 feet long and 2.705 inches diameter, would empty itself in 3 minutes and 16 seconds, through an orifice in the bottom, whose area

is .0141 inches; and another 6.458 feet long, the diameter and orifice, as before, would do the same in 4 minutes and 40 seconds; hence, from these experiments, a rule is obtained, namely,

Multiply the square root of the depth in feet by the area of the falling surface in inches, divide the product by the area of the orifice, multiplied by 3.7, and the quotient is the time required in seconds, nearly.

EXAMPLE.—How long will it require to empty a vessel of water, 9 feet high, and 20 inches diameter, through a hole $\frac{3}{4}$ inch in diameter?

$\sqrt{9} = 3$, the square root of the depth,
314.16 inches, area of the falling surface,
.4417 inches, area of the orifice;

Then, $\frac{314.16 \times 3}{.4417 \times 3.7} = 576.7$ seconds, or
9 minutes and 36 seconds.

On the pressure of fluids.

The side of any vessel containing a fluid sustains a pressure equal to the area of the side, multiplied by half the depth; thus,

Suppose each side of a vessel to be 12 feet long and 5 feet deep, when filled with water, what pressure is upon each side?

$12 \times 5 = 60$ feet, the area of the side,
2.5 feet = half the depth, and
62.5 lbs. = the weight of a cubic foot of water.

Then, $60 \times 2.5 \times 62.5 = 9375$ lbs.

To find the number of imperial gallons contained in a yard of pipe of any given diameter.

RULE.—Square the diameter of the pipe in inches, cut off one integer for a decimal; again, multiply the square by 2, the product is hundredths, &c., of a

gallon, which add to the former product, and the sum will be the content of the pipe in imperial gallons nearly,

EXAMPLE 1.—Required the number of imperial gallons contained in each yard of a $6\frac{1}{4}$ inch pipe.

$6.25^2 = 39.0625$ and $3.90625 \times 2 = 78125$.

Then, 3.90625

$+ \quad 78125$

$= 3.984375$ gallons.

EXAMPLE 2.—Required the content of a yard of 4 inch pipe in imperial gallons.

$4^2 = 16$, and $16 \times 2 = 32$, then 1.6

$+ \quad 32$

$= 1.632$ gallons.

To find the weight that a given power can raise by one of Bramah's pumps, or hydrostatic presses.

RULE.—Multiply the square of the diameter of the ram in inches by the power applied in lbs., and by the effective leverage of the pump handle; divide the product by the square of the pump's diameter, also in inches, and the quotient is the weight that the power is equal to.

EXAMPLE.—What weight will a power of 50 lbs. raise by means of an hydrostatic press, whose ram is 7 inches diameter, pump $\frac{7}{8}$, and the effective leverage of the pump handle being as 6 to 1?

$$\frac{7^2 \times 50 \times 6}{.875^2} = 19200 \text{ lbs., or 8 tons 11 cwt.}$$

In the following rules for pumping engines the boiler is supposed to be loaded with about $2\frac{1}{2}$ lbs. per square inch, and the barometer attached to the condenser indicating 26 inches on an average, or 13 lbs. $= 15\frac{1}{2}$ lbs., from which deduct $\frac{1}{5}$ for friction, leaves a pressure of 10 lbs. nearly upon each square inch of the piston.

To find the diameter of a cylinder to work a pump of a given diameter for a given depth.

RULE.—Multiply the square of the pump's diameter in inches by $\frac{1}{3}$ of the depth of the pit in fathoms, and the square root of the product will be the cylinder's diameter in inches.

EXAMPLE.—Required the diameter of a cylinder to work a pump 12 inches diameter and 27 fathoms deep.

$$\sqrt{12^2 \times 9} = 36 \text{ inches diameter.}$$

To find the diameter of a pump that a cylinder of a given diameter can work at a given depth.

RULE.—Divide three times the square of the cylinder's diameter in inches by the depth of the pit in fathoms, and the square root of the quotient will be the pump's diameter in inches.

EXAMPLE.—What diameter of a pump will a 36 inch cylinder be capable of working 27 fathoms deep?

$$\sqrt{\frac{36^2 \times 3}{27}} = 12 \text{ inches diameter.}$$

To find the depth from which a pump of a given diameter will work by means of a cylinder of a given diameter.

RULE.—Divide three times the square of the cylinder's diameter in inches by the square of the pump's diameter also in inches, and the quotient will be the depth of the pit in fathoms.

EXAMPLE.—Required the depth that a cylinder of 36 inches diameter will work a pump of 12 inches diameter.

$$\sqrt{\frac{36^2 \times 3}{144}} = 27 \text{ fathoms.}$$

APPROXIMATE RULES FOR CALCULATING LIQUIDS.

To find the number of imperial gallons contained in any square or rectangular cistern.

RULE.—Multiply the content of the cistern in cubic feet by 6.232, or the content in cubic inches by .003607, and the product is the number of gallons nearly.

EXAMPLE 1.—A cistern that is 8 feet long, $4\frac{1}{2}$ feet wide, and 3 feet deep, required its contents in imperial gallons.

$8 \times 4.5 \times 3 = 108$ cubic feet.

And $108 \times 6.232 = 673.056$ gallons.

Or, 8 feet = 96 inches; $4\frac{1}{2}$ feet = 54 inches, and 3 feet = 36 inches; then,

$96 \times 54 \times 36 = 186624$ cubic inches,

And $186624 \times .003607 = 673.152$ gallons.

Any two dimensions of a square or rectangular cistern being given, to find the third, that shall contain any number of imperial gallons required.

RULE.—Divide the number of gallons that the cistern is required to contain by the product of the two dimensions multiplied by either of the multipliers as above, according as the dimensions are given in feet or inches, and the quotient will be the third dimensions of the cistern nearly.

EXAMPLE.—Required the depth of a cistern to contain 800 imperial gallons, the length being $6\frac{1}{2}$ feet, and width $4\frac{3}{4}$ feet.

$6.5 \times 4.75 \times 6.232 = 192.413$; and

$800 \div 192.413 = 4.16$ feet deep.

To find the content of a cylinder in imperial gallons.

RULE.—Multiply the square of the diameter in feet by the length of the cylinder, also in feet, and by 4.895;

Or, the square of the diameter in inches by the length in feet and by 0.34;

Or, the square of the diameter in inches by the length also in inches, and by .002832, and the product will be the content in gallons nearly.

EXAMPLE.—How many imperial gallons are contained in a well 22½ feet deep, and 3½ feet diameter?

$$3.5^2 \times 22.5 \times 4.895 = 1349.18 \text{ gallons.}$$

Or, 3½ feet = 42 inches,

And, $42^2 \times 22.5 \times .034 = 1349.46$ gallons.

Also, 22½ feet = 270 inches,

And, $42^2 \times 270 \times .002832 = 1349.3$ gallons.

The length of a cylinder given, to find the diameter, or the diameter given, to find the length that shall contain any number of imperial gallons required.

RULE.—Divide the number of gallons that the cylinder is required to contain, by the length in feet multiplied by 4.895, and the square root of the quotient is the diameter in feet, and parts of a foot;

Or, divide the number of gallons by the square of the diameter in feet multiplied by 4.895, and the quotient is the length in feet and parts of a foot,—and

If the dimensions are in inches in place of feet, use 354 in place of 4.895.

EXAMPLE.—What must be the diameter of a cylinder to contain 5 imperial gallons, when the length is 20 inches?

$$\sqrt{\frac{354 \times 5}{20}} = 9.4 \text{ inches diameter.}$$

The cube of the diameter of a sphere in feet, multiplied by 3.263 = imperial gallons;

Or, the cube of the diameter of a sphere in inches, multiplied by .001888 = imperial gallons.

NOTE.—The weight of a cubic foot of water = 62.5 lbs. avoirdupois.

Weight of a cubic inch = .03617 lbs. avoirdupois.

Weight of a column of water 12 inches high and 1 inch square = .434 lbs. avoirdupois.

Weight of a cylindrical foot of water = 49.1 lbs. avoirdupois.

Weight of a cylindrical inch = .02842 lbs. avoirdupois.

Weight of a column of water 12 inches high and 1 inch diameter = .341 lbs. avoirdupois.

Take for example a column of water 11 inches diameter and 15 feet high, required its weight.

$11^2 \times 15 \times .341 = 618.915$ lbs. avoirdupois.

11.2 imperial gallons of water = 1 cwt.

224 imperial gallons of water = 1 ton.

1.8 cubic feet of water ..... = 1 cwt.

35.84 ..... = 1 ton.

1 ..... = $6\frac{1}{4}$ imperial gallons.

1 cylindrical foot ..... = 5 imperial gallons.

OF STEAM AND THE STEAM ENGINE.

Steam is the visible moist vapour which arises from all bodies that contain juices easily expelled from them by heats not sufficient for their combustion.

But steam, as applicable at present to the steam-engine, is highly rarified water, the particles of which are expanded by the absorption of caloric, or the matter of heat.

Water rises in vapour at all temperatures, but is confined to the surface of the fluid acted upon until it has attained 212° Fahrenheit, called the boiling point; at that heat steam ascends through it, preventing its elevation to a higher temperature by carrying the heat off in a latent form.

The latent heat of steam at the common pressure of the atmosphere, according to very accurate experiments, is found to be 1000°; and we know that the sensible, or thermometric heat = 212°.—Now 212° − 32° = 180°, and 1000 + 180 = 1180°; therefore, steam at 212° is highly rarified water, containing 1180° of heat; hence, to find the latent heat of steam at any other temperature, subtract the sensible heat from 1180°, and the difference + 32° = the latent heat.

EXAMPLE.—Required the latent heat of steam whose sensible heat is 224°.

1180 − 224 = 956,

And 956 + 32 = 988° latent heat.

One cubic inch of water produces about 1700 cubic inches of steam at 212°, or the common pressure of the atmosphere; but the boiling point varies considerably, according to the pressure on the surface of the fluid, and, of course, materially affects the density of the vapour produced; thus, in a vacuum, water boils at about 90°; under common pressure, at 212°; and when pressed with a column of mercury 5 inches in height, will not boil

until heated to 217°; each inch of mercury producing by its pressure a rise of about 1° in the thermometer.

The pressure or force of steam in the boiler (less than the weight upon the safety valve) is generally indicated by a column of mercury in a bent iron tube, which causes the range of the float to be only half the range of the mercury, 2 inches of mercury being nearly equal to 1 lb. pressure of steam in the boiler, thus :—

Each inch of the float indicates a pressure of 1*lb. nearly.*

—Level of the mercury when there is no pressure of steam.

To calculate the effect of a lever and weight upon the safety valve of a steam boiler, &c.

The lever, in all cases, is supposed to be made finished, and balanced, by a known weight or weights, on the short end, making that point where it rests, or is attached to the valve, the centre of motion; then that weight, added to the weight of the lever, is the effective weight upon the valve, independent of any other additional weight, thus:

Then there are three different ways that it may be required to calculate the lever.

1.—*When a certain pressure may be required upon the valve, the distance of the weight upon the lever, and distance of the valve from the centre of motion given, to find what weight will be required upon the lever at that distance.*

Rule.—From the required pressure on the valve in lbs. subtract the weight of the valve, plus the effective weight of the lever, multiply the remainder by the distance between the fulcrum and the valve, divide the product by the distance between the fulcrum and the weight, and the quotient is the weight in lbs. required to be placed upon the lever at that distance.

2.—*When a certain pressure upon the valve is required, the weight upon the lever and distance of valve from the centre of motion given, to find where that weight must be placed.*

Rule.—From the required weight upon the valve in lbs. subtract the weight of the valve, plus the effective weight of the lever, multiply the remainder by the distance between the fulcrum and the valve, divide the product by the weight in lbs. upon the lever, and the quotient is the distance in inches from the fulcrum that the weight must be placed.

3.—*When the distance of weight, distance of valve from the centre of motion, and weight upon the lever given, to find what pressure is upon that valve.*

Rule.—Multiply the weight in lbs. upon the lever by the distance in inches to the fulcrum, divide the product by the distance between the fulcrum and the valve, and the quotient, plus the weight of the valve and effective weight of the lever, equal the weight upon the valve in lbs.

Example 1.—Suppose the lever A B (as above) to be 24 inches in length, and the valve C placed 5

inches from the centre of motion A, what weight must be placed upon the lever 20 inches from A, to equal 80 lbs. on the valve C, the weight of the lever being 2 lbs., the weight D, which balances the lever, $4\frac{1}{2}$ lbs., and the weight of the valve 3 lbs.

2 lbs, weight of the lever.
4.5 to balance ditto.
3 weight of the valve.
9.5 lbs. then $\frac{80 - 9.5 \times 5}{20} = 17.625$ lbs.

EXAMPLE 2.—Suppose, as in the last example, the weight upon the lever equal 17.625 lbs., it is required at what distance from A the weight must be placed to equal 80 lbs. at C.

$$\frac{80 - 9.5 \times 5}{17.625} = 20 \text{ inches.}$$

EXAMPLE 3.—Suppose, as before, that a weight of 17.625 lbs. is placed upon the lever 20 inches from A, required the pressure at C, the distance from the centre of motion being 5 inches, and the effective weight of the lever at that point equal $6\frac{1}{2}$ lbs., also the weight of the valve 3 lbs.

$$\frac{17.625 \times 20}{5} = 70.5$$
$$+ \quad 6.5$$
$$+$$
$$= 80 \text{ lbs.}$$

To find the proper diameter for a safety valve.

RULE.—Multiply the bottom surface of the boiler, or surface immediately exposed to the action of the fire, in feet, by the multiplier opposite to the pressure in lbs. on each square inch of the safety valve, and the square root of the product is the valve's diameter in inches at the narrowest part. If the boiler is to have two safety

valves, then the square root of half the product equal the diameter of each.

Pressure in lbs. per square inch.	Multipliers.	Pressure in lbs. per square inch.	Multipliers.
3	.356	15	.315
4	.353	20	.305
5	.348	25	.293
6	.344	30	.289
7	.339	35	.282
8	.336	40	.275
10	.329	45	.270
12	.321	50	.264

Table of the elastic force of steam on a square inch.

Steam with a pressure of	lbs. on a square inch, equal	lbs. on a circular inch; and to maintain that pressure requires to be kept at a uniform temperature of	° F	and will support a column of mercury	inches in height.
2½	1.963		220	5.15	
3	2.356		222	6.18	
3½	2.749		223½	7.21	
4	3.141		225½	8.24	
4½	3.534		227	9.27	
5	3.927		228½	10.3	
5½	4.320		230	11.3	
6	4.712		231½	12.3	
6½	5.105		233	13.4	
7	5.498		234	14.4	
7½	5.890		235	15.4	
8	6.283		236	16.5	
8½	6.676		237½	17.5	
9	7.068		239	18.5	
9½	7.461		240	19.6	
10	7.854		241	20.6	
10½	8.247		242	21.6	
11	8.639		243	22.6	
11½	9.032		244	23.7	
12	9.424		245½	24.7	
15	11.78		252	30.9	
20	15.71		261	41.2	
25	19.63		269	51.5	
30	23.56		276	61.8	
35	27.49		283	72.1	
40	31.41		289	82.4	
45	35.34		294½	92.7	
50	39.27		300	103	

Multiply the degrees of heat in either this or the following table by .06, and the product will be the

superficial feet of fine plate exposed to the action of the fire for each horse power.

And multiply the degrees of heat by .41, and the product will be the areal inches of furnace bar for each horse power.

Table of the elastic force of steam on a circular inch.

Steam with a pressure of	lbs. on a circular inch, equal	lbs. on a square inch; and to maintain that pressure requires to be kept at a uniform temperature of	and will support a column of mercury	inches in height.
2¼	3.183	222¼°	6.56	
3	3.819	224½	7.87	
3½	4.456	226¾	9.18	
4	5.093	228¾	10.5	
4½	5.729	230½	11.8	
5	6.366	232	13.1	
5½	7.002	234	14.4	
6	7.639	235¼	15.7	
6½	8.276	236¾	17.0	
7	8.912	238¼	18.3	
7½	9.549	239½	19.7	
8	10.18	241	21.0	
8½	10.82	242¼	22.3	
9	11.45	244	23.6	
9½	12.09	245¼	24.9	
10	12.73	247	26.2	
10½	13.36	248½	27.5	
11	14.00	250	28.9	
11½	14.64	251	30.1	
12	15.27	252½	31.5	
15	19.09	259	39.3	
20	25.46	270	52.5	
25	31.83	278¼	65.6	
30	38.19	287	78.7	
35	44.56	294	91 8	
40	50.92	300½	105	
45	57.20	305	118	
50	63.66	309	131	

Proportions of fuel.

The proportion that various substances bear to each other in producing heats sufficient to raise equal quan-

tities of water to equal temperatures are nearly as follows:

Coke	0.375	Culm or Slack	1.875
Coal	1.000	Wood	2.875

Hence, multiply the degress of heat in either of the preceding tables by the following numbers opposite the material by which the steam is to be produced, and the product will be the weight in lbs. avoirdupois that is required on an average per hour for each horse power:—

Coke	.024	Slack	.118
Coal	.063	Wood	.18

To find the height of a column of water to supply a steam boiler against any pressure of steam required.

RULE.—Multiply the pressure in pounds (upon a square inch of the boiler) by 2.5, and the product will be the height in feet above the surface of water in the boiler.

EXAMPLE.—Required the length of feed pipe capable of supplying a boiler with water when the pressure of steam is 4 pounds per square inch.

$2.5 \times 4 = 10$ feet above the surface of the water in the boiler.

STEAM ENGINE is the name of a machine which derives its moving powers from the elasticity and condensibility of steam.

Steam, to produce a maximum of useful effect as a moving power, requires to be reduced to a certain determined velocity, and although this maximum velocity has been exhibited to the public by various eminent writers upon the steam engine, still discrepancies exist amongst practical engineers; and no universally acknowledged rules have as yet been established; however, the following tables may be relied upon as exhibiting the results deduced from the most celebrated

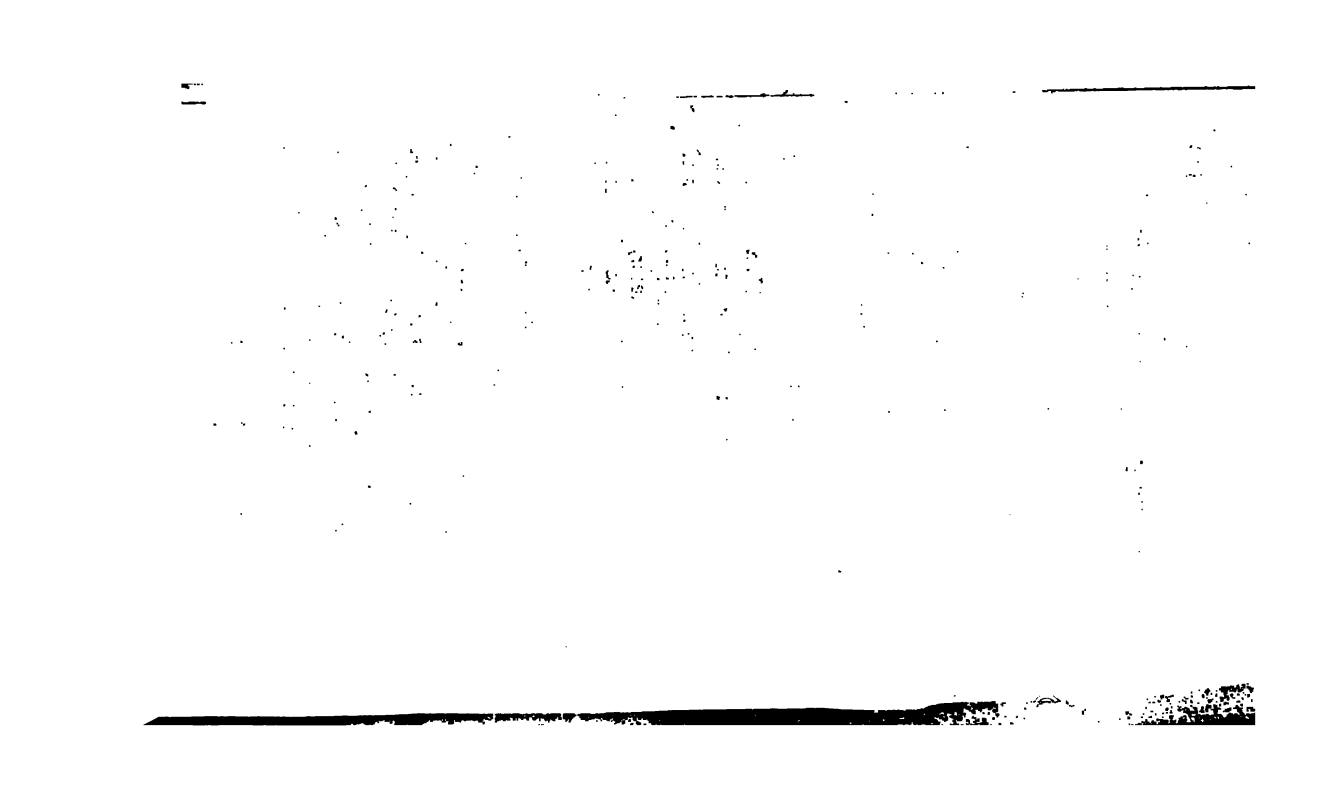
rules, and tested by many engines doing the greatest amount of duty, as proved by accurate trials with indicators of the most recent and approved construction.

Length of Stroke in Ft. and In.	Number per Minute.	Velocity in Feet per Minute.	Length of Stroke in Ft. and In.	Number per Minute.	Velocity in Feet per Minute.
2 0	43	172	4 6	24¼	218¼
2 6	38	190	5 0	22	220
3 0	34	204	6 0	19	228
3 6	30	210	7 0	17½	245
4 0	27	216	8 0	16	256

N.B.—These are to be considered as the velocities of land engines, or engines whose connecting rods are not less than three times the length of stroke; but marine engines, being generally confined to connecting rods of not more than 2 or 2½ times the length of stroke, have heir maximum velocities considerably reduced. Hence, the subjoined table will be found pretty correct when the periphery of the wheels moves with a velocity of about 1300 feet per minute, and the floats, or paddle boards, calculated by the following rules, which I have found, in practice, to produce the greatest satisfaction, namely, economizing of fuel, a steady supply of steam, without waste, and the vessel propelled quicker than when the surface of the floats was less, and moving at a greater velocity.

Table of velocities for marine engines.

Length of Stroke in Ft. and In.	Number per Minute.	Velocity in Feet per Minute.	Length of Stroke in Ft. and In.	Number per Minute.	Velocity in Feet per Minute.
2 0	42	168	4 0	24	192
2 3	39½	177¾	4 6	21½	193½
2 6	36	180	5 0	20	200
2 9	33	181	5 6	19	209
3 0	31	186	6 0	18	216
3 6	27	189	7 0	15¾	220½



l the surface of the floats or paddle boards.

1.—Multiply the number of horses' power
ngine is equal to by 3.75, divide the product
meter of the wheel in feet, and the quotient
of each float, or paddle board.

2.—Multiply the area of the floats by .54,
ct is the length in feet; then divide the area
gth, and the quotient is the breadth.

LE.—Required the area, length, and breadth
ddle board, for a steam vessel with two en-
0-horse power each, and wheels of 20 feet

$$\frac{\times\ 3.75}{20} = 15 \text{ feet area.}$$

$\times\ .54 = 8.1$ feet the length of each board.

$\div\ 8.1 = 1.85$ or 1 foot 10 inches in breadth.

hen there is only one engine in the vessel,
uotient is the area of each board nearly.
heel, from 12 to 14 feet diameter, ought to
oats; from 14 to 16 feet diameter, 14 floats;
o 18 feet diameter, 16 floats; and from 18
diameter, 18 floats, &c.

upon which the rule is founded for calculating the power of a steam engine.

o it has been customary, in estimating the
condensing engines, to reckon the force of
at a constant quantity, namely, $2\frac{1}{2}$ lbs. per
ch, totally disregarding any extra pressure in
or increased weight upon the safety valve.
in order to form a rule whereby to approxi-
nearly to the real effective power of the en-
as necessary first to ascertain the effective
e steam,—And,
rmine this, I recently made a series of experi-
n engines without any extra lap upon the

valves, whereby to work expansively, when I found that, on account of the nature of the valve's motion, only about three-fourths of the stroke was performed by steam at, or near, the density of the steam in the boiler, the stroke, of course, being terminated expansively; hence, the whole effective force of the steam thus applied can only be taken at about four-fifths of its original pressure.

The benefit arising from the condenser is on an average equal to 26 inches of mercury, or about 13lbs. per square inch, consequently, 13 plus four-fifths of the pressure on each square inch of the safety valve, equal the whole effective force on each square inch of the piston's area.

Then about $8\frac{1}{4}$lbs. is expended in overcoming the resistance and friction of a condensing engine, and may be thus estimated: 13 minus $8\frac{1}{4}$ equal $4\frac{3}{4}$, and $4\frac{3}{4}$ plus $\frac{4}{5}$ths of the weight upon each square inch of the safety valve equal the whole amouut of useful effect in giving motion to machinery.

The process of calculation may be simplified thus: $4\frac{3}{4}$lbs. per square inch = 3.73 lbs. per circular inch, by which means the circle only requires to be squared, and the labour of multiplying by .7854 is dispensed with.

GENERAL RULES.

1.—Multiply the square of the cylinder's diameter in inches by 3.73 plus $\frac{4}{5}$ths the pressure on each circular inch of the safety valve, and by the velocity of the piston in feet per minute; divide the product by 33000, and the quotient is the effect of the engine expressed in horses' power.

EXAMPLE.—Suppose a cylinder $24\frac{1}{2}$ inches diameter, stroke 4 feet, or 200 feet velocity per minute, and the

weight upon the safety valve 3.5 lbs. per circular inch, required the effective power.

$\frac{4}{5}$ths of 3.5 = 2.8, and 3.73 + 2.8 = 6.53 lbs. effective force.

Then $\frac{24.5^2 \times 6.53 \times 200}{33000} = 24$ horses' power.

2.—Multiply 33000 by the number of horses' power required, and divide the product by the velocity of the piston in feet per minute, multiplied by 3.73 plus $\frac{4}{5}$ths the pressure on each circular inch of the safety valve, and the square root of the quotient is the cylinder's diameter in inches.

EXAMPLE.—Required the diameter of a cylinder for an engine of 30 horses' power, with a 6 feet stroke, or 228 feet per minute, and steam at 2½ lbs. per circular inch.

$\frac{4}{5}$ths of 2.5 = 2; and 3.73 + 2 = 5.73 lbs. effective force.

Hence, $\frac{33000 \times 30}{228 \times 5.73} = \sqrt{758} = 27\frac{1}{2}$ inches diameter.

NOTE.—To obtain four-fifths of the pressure of steam, multiply the original pressure by 4 and divide by 5, the quotient is the pressure required.

The above are to be taken as general practical rules for engines not working expansively further than what is compulsory from the nature of the slide valve, but where engines are worked more expansively, and greater accuracy required, recourse must be had to the following rules for obtaining the uniform force of the steam.

RULE 1.—Divide the length of the stroke in inches by the distance (also in inches) that the piston moves before the steam is shut off, and divide the pressure on the boiler in lbs. by the quotient :—

2.—Add 1 to the hyperbolic logarithm of the number of times to which the steam is expanded, and multiply the logarithm by the number of lbs. to which the steam is expanded, and the product is the uniform force of the steam acting throughout the whole stroke.

EXAMPLE.—Let the steam in the boiler of an engine equal 45 lbs. per inch, the length of stroke 4 feet, and the steam to be shut off after the piston has moved 16 inches; required an equivalent force of steam in the cylinder.

4 feet = 48 inches, and 48 ÷ 16 = 3.

Then, 45 ÷ 3 = 15 lbs. And, 1 + 1.0986123 = 2.0986123 × 15 = 31.4791845 lbs. uniform force of the steam.

HYPERBOLIC LOGARITHMS.

No.	Log.	No.	Log.	No.	Log.	No.	Log.
1¼	.2231435	3¼	1.1786549	5¼	1.6582280	7¼	1.9810014
1½	.4054651	3½	1.2527629	5½	1.7047481	7½	2.0149030
1¾	.5596157	3¾	1.3217558	5¾	1.7491998	7¾	2.0476928
2	.6931472	4	1.3862943	6	1.7917594	8	2.0794415
2¼	.8109302	4¼	1.4469189	6¼	1.8325814	8½	2.1400661
2½	.9162907	4½	1.5040774	6½	1.8718021	9	2.1972245
2¾	1.0116008	4¾	1.5581446	6¾	1.9095425	9½	2.2512917
3	1.0986123	5	1.6094379	7	1.9459101	10	2.3025851

THE STEAM WAY.

Multiply any cylinder's area by .034, and the product will be the area of port or steam way.

EXAMPLE.—What area of port or steam way is necessary for a cylinder 36 inches diameter?

36 inches diameter = 1017.8 inches area × .034 = 34.6 inches area of steam way.

OF THE SLIDE VALVE.

When the valve is at the middle of its stroke, the faces ought to cover the apertures on the exhausting side about $\frac{1}{10}$ of an inch; the cover on the steam side being for the purpose of cutting off the steam at any part of the stroke, is, therefore, at the entire discretionary judgment of the engineer. However, we find from practice, that high-pressure engines with short strokes, as locomotives, &c., require no more than will cover the apertures properly; whereas condensing engines, with steam of $2\frac{1}{2}$ to 3 lbs. per square inch, will work well with $\frac{5}{8}$ of an inch cover on the steam side; and marine engines give great satisfaction with $1\frac{5}{8}$ inches cover, when the steam is $4\frac{1}{2}$ lbs. to 5 lbs. per square inch.

Again, the lead of the valve (as it is termed amongst engineers) is a certain distance that the extremity of the eccentric must be in advance of the crank, so that the valve may be open as required when the piston is at the top or bottom of the cylinder,—for this reason, that, at the return of the stroke, the steam in the cylinder may be of, or nearly, an equal density with the steam in the boiler; consequently, the nearer that the length of the aperture is to the area of the cylinder, the less lead is required. Thus,

Suppose a cylinder of 48 inches diameter, with an aperture 16 inches long, $\frac{48^2}{16} = 144$; and another 24 inches diameter, with an aperture 8 inches long, $\frac{24^2}{8} = 72$; then $\frac{144}{72} = 2$. Hence it is evident that, although both apertures bear the same proportion to the diameter of the cylinder, and both valves move the same distance, the 48 inch cylinder would be twice the time in filling with steam to that of the 24 inch, for a cylinder twice the diameter is four times the area; but scarcely two engineers agree upon this point. However, the following is an approximate rule to a number

of celebrated working engines, namely: Multiply the square of the cylinder's diameter in inches by .002, and divide the product by the length of the aperture, also in inches; the quotient will be the width that the valve must be open when the piston is exactly at the top or bottom of the cylinder.

EXAMPLE.—Let a cylinder be 30 inches diameter, with an aperture 12 inches long.

$$\frac{30^2 \times .002}{12} = .15$$ parts of an inch for the aperture to be open at the return of the stroke.

THE ECCENTRIC.

1.—The length of the levers on the weigh or traverse shaft given, to find the required throw of the eccentric.

RULE.—Multiply the distance that the valve is to travel by the length of the lever on the weigh shaft for the eccentric rod; divide the product by the length of the lever for working the valve, and the quotient is the throw of the eccentric.

EXAMPLE.—Let a valve be required to travel 6 inches, the lever on the weigh shaft for working the valve 12 inches in length, and the lever for the eccentric rod 10 inches; required the throw of that eccentric.

$$\frac{6 \times 10}{12} = 5$$ inches throw.

The throw of the eccentric is the distance between A and B on that eccentric.

2.—The throw of the eccentric and the stroke of the valve, also one of the levers on the weigh shaft given, to find the other.

RULE.—Multiply the throw of the eccentric by the length of the lever to work the valve, and divide by the distance the valve is to travel; the quotient will be the length of the other lever. Or,

Multiply the travel of the valve by the length of the lever on the weigh shaft, for the eccentric rod, and divide by the throw of the eccentric; the quotient will be the length of the lever for working the valve.

EXAMPLE.—Suppose a valve be required to travel 6 inches, the throw of the eccentric 5, and the length of the lever on the weigh shaft for working equal 12 inches; required the length of the other.

$$\frac{5 \times 12}{6} = 10 \text{ inches; or}$$

$$\frac{6 \times 10}{5} = 12 \text{ inches.}$$

THE COLD WATER PUMP.

Taking practice as a data whereby to determine the quantity of water sufficient for condensation in all ordinary cases of the steam engine, I find that, at the common temperature of the atmosphere, four imperial gallons of water to each horse power are quite capable of condensing steam at 220° Faht. to water at 80°; but if the temperature of the steam be raised, the quantity of water must be augmented, according to the result of the following

RULE.—Multiply the temperature of the steam in the boiler by .019, and the product will be the quantity required in imperial gallons per minute to each horse power. Hence, to find the diameter of the pump, when the stroke is given, or the stroke of the pump, when the diameter is given,

Multiply the quantity required in gallons for each horse power by the number of horses' power that the engine is equal to, and by 353; divide the product by the intended stroke of the pump in inches multiplied by the number of strokes per minute, and the square root of the quotient is the pump's diameter in inches.—

Or, divide the product by the number of strokes per minute multiplied by the square of the pump's diameter, and the quotient is the length of the stroke.

EXAMPLE.—Let an engine of 25 horses' power be propelled by steam at 7 lbs. per square inch, what must be the pump's diameter when the stroke is 23 inches, and making 22 strokes per minute?

7 lbs. per square inch = 234°; and

$234 \times .019 = 4.446$ gallons to each horse power.

Then $\frac{4.446 \times 25 \times 353}{23 \times 22} = \sqrt{77.54} = 8.8$ inches diameter nearly.

Or, $\frac{4.446 \times 25 \times 353}{77.54 \times 22} = 23$ inches length of stroke.

NOTE.—The diameter of the injection cock ought to be at least equal to $\frac{1}{12}$th of the cylinder's diameter.

To find the necessary quantity of water for a boiler.

RULE.—Add 15 to the pressure on each square inch of the boiler in lbs., divide the sum by 18, multiply the quotient by .2, and the product is the quantity in imperial gallons per minute for each horse power. Hence, the rule for the cold water pump is also applicable for the hot water pump.

EXAMPLE.—Suppose a 6 horse engine to be propelled by steam at 30 lbs. per square inch, stroke of pump 9 inches, and making 45 strokes per minute, required the pump's diameter.

$\frac{30 + 15}{18} = 2.5 \times .2 = .5$ of a gallon per minute to each horse power.

Then $\frac{.5 \times 6 \times 353}{45 \times 9} = \sqrt{2.6} = 1.6$ inches diameter, nearly.

Or, $\frac{.5 \times 6 \times 353}{45 \times 2.6} = 9$ inches length of stroke.

THE AIR PUMP.

The *Air Pump* for a land engine generally requires to be larger in proportion to the cylinder than the air pump for a marine engine, on account of having frequently to condense with water at a higher temperature; hence, when the stroke of the bucket is half the stroke of the piston, multiply the cylinder's diameter in inches by .67, and the product is the diameter of air pump.—Again, multiply the diameter of the cylinder of a marine engine, in inches, by .575, and the product is the diameter of air pump,

EXAMPLE.—What diameter of air pump is requisite for an engine whose cylinder is 28 inches diameter?

$$28 \times .67 = 18.76 \text{ inches diameter.}$$

When the stroke of the bucket is either more or less than half the stroke of the piston, the pump's diameter will then be obtained by the following

RULE.—Square the given diameter, multiply by the length, and divide by the length proposed, extract the square root, and the product will be the diameter.

EXAMPLE.—Suppose an engine with a 4 feet stroke required an air pump 26 inches diameter with a 2 feet stroke, but necessity requires it to be 6 inches nearer the end of the beam, what must be the diameter of air pump, the beam being 11 feet long?

Radius of beam = 66 inches. Then,

As $66 : 48 :: 39 : 28.36$ inches, length of stroke;

And $\sqrt{\frac{26^2 \times 24}{28.36}} = 24$ inches, diameter of pump nearly.

The *Condenser* ought to be a little more in capacity than the air pump; but in the case of marine engines, where the bottom of the condenser and bottom of the cylinder are nearly on a level, care must be taken to make the passage between the valves and condenser large enough to contain the condensing water required

for one stroke of the piston, besides leaving a proper communication, otherwise the connexion between the cylinder and condenser will be cut off by water of nearly 100° of heat, on account of the cylinder being twice filled with steam for each effective stroke of the air pump.

The area of air pump multiplied by .25 will give the area of foot and discharging valves; thus, 24 inches diameter = 452.39 inches area, × .25 = 113.0975 inches, area of valves.

The piston rod is about $\frac{1}{10}$ of the cylinder's diameter; the air pump rod in the same proportion, unless it be made of copper, and then it may be about $\frac{1}{8}$ of the pump's diameter.

THE BEAM.

When a beam is applied to an engine its length ought not to be less than three times the length of the stroke, and its breadth half the stroke, or in high pressure engines $\frac{2}{3}$ of the stroke; also its best form is a parabola.

To find the thickness of a beam, when the length, breadth, and diameter of the cylinder are given.

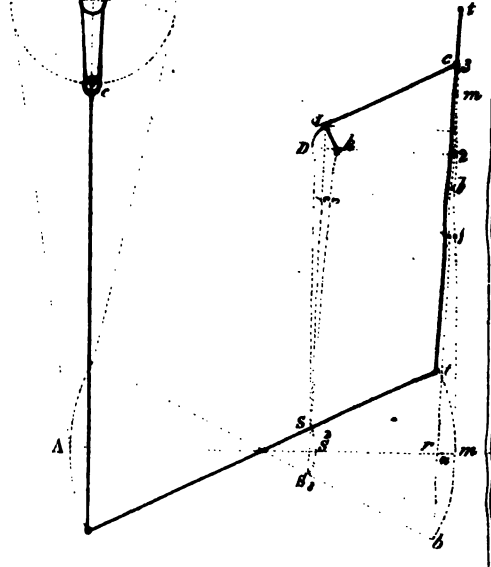
RULE.—Multiply the whole pressure of steam on the piston in lbs. by half the length of the beam in feet, and divide the product by 70 times the square of the breadth in inches, and the quotient will be the thickness in inches nearly.

EXAMPLE.—What thickness of beam is requisite for an engine whose cylinder is 25 inches diameter, the length of the beam being 15 feet, length of stroke 5 feet, and the effective pressure on each square inch of the piston equal 15 lbs.

Area of piston = 490.875 inches.

And $\frac{490.875 \times 15 \times 7.5}{30^2 \times 70}$ = .876 or $\frac{7}{8}$ of an inch in thickness nearly.

Fig 3ᵉᵘ . *A motion that is chiefly used in marine Engines.*



To find the versed sine of the arc described by the beam of an engine.

RULE.—Divide the square of half the length of the stroke in inches, by the length of the beam also in inches, and the quotient is the versed sine.

EXAMPLE.—Required the versed sine of the arc described by an engine beam 12 feet in length, the chord of the arc or length of the stroke being 4 feet.

$$\frac{24^2}{144} = 4 \text{ inches the versed sine.}$$

NOTE.—When the beam is not equal lengths at each end from the centre on which it vibrates, the length is then to be taken equal to twice the radius of that end of which the versed sine is required.

THE PARALLEL MOTION.

The beam being given, to find the length of the radius rods.

RULE.—Divide the square of the distance between A and B, on the beam, by the distance between B and C, and the quotient is the length of the radius rod $d\ x$.

FIG. 1, EXAMPLE.—Suppose a beam 12 feet long, and the stud for the back links 39 inches from the centre, required the length of radius rods.

Radius of beam = 72 inches, and $72 - 39 = 33$

then $\frac{39^2}{33} = 46.09$ inches.

NOTE.—The length of the front and back links equal half the length of the stroke.

FIG. 2, EXAMPLE.—Suppose $b\ d = 32\frac{1}{4}$, and $d\ a = 35\frac{1}{4}$, to find d F.

$$\frac{32.25^2}{35.25} = 29.5 \text{ inches nearly.}$$

FIG. 3.—As the calculation of this motion is rather tedious, on account of the various angles formed by the

side rods, it is considered better to lay it down in the following geometrical form :—

Upon the line **A** *m*, with the radius of the beam, describe the arc *b m t ;* from *m*, with half the length of stroke, cut the arc in *b* and *t*, draw the line *b t* and *r m* equal the versed sine described by the beam ; bisect *r m* in *n*, and erect a perpendicular line for the centre of the cylinder. Again, from *b m t*, with the length of the side rods, cut the perpendicular line ; at the bottom, middle, and top stroke of the cross-head draw the lines *b b*, *m m*, *t t ;* from the end of the cross-head, or top of the side rods, with any convenient distance, set off the pin or stud in the side rod for the end of the parallel bar 1, 2, 3, from which, with the distance *s t*, describe arcs at *d* D *d ;* draw the lines *d* 1, D 2, &c. Then the length of the crank may be found either by the sixth problem in Geometry, or the eighth problem in Mensuration.

THE CONNECTING ROD.

The proportionate length of connecting rod is three times the length of stroke, which determines the perpendicular distance between the centre of the beam and centre of fly-wheel shaft. Or, if the engine is erected, the length of connecting rod is the perpendicular distance between the centre of the fly-wheel shaft and centre of the beam.

THE FLY WHEEL.

To find the weight of the rim or ring of a fly-wheel proper for a steam engine.

Rule.—Multiply the constant number, 1368, by the number of horses' power that the engine is equal to ; divide the product by the diameter of the wheel, in feet, multiplied by the number of revolutions per minute ; and the quotient is the weight of the ring in cwts. nearly.

Example.—Required the weight of the rim of a fly-wheel proper for an engine of 20 horses' power, the

wheel to be 16 feet diameter, and make 21 revolutions per minute.

$$\frac{1368 \times 20}{16 \times 21} = 81.4 \text{ cwt. nearly.}$$

NOTE.—The fly-wheel of an engine for a corn or flour mill ought to be of such a diameter that the velocity of the periphery of the wheel may exceed the velocity of the periphery of the stones, to prevent, as much as possible, any tendency to back lash, as it is termed.

The necessary weight and diameter of the wheel being found, suppose a breadth of rim, and the thickness to make the weight in cast iron will be found by the following

RULE.—Divide the required weight in lbs. by the area of the ring in inches, multiplied by .263, and the quotient is the thickness of the ring in inches.

EXAMPLE.—What thickness must a ring be to equal 81.4 cwts. when the outer diameter is 16 feet, and the inner diameter 14 feet 8 inches?

81.4 cwts. = 9116.8 lbs.

And, by Problem XII in Mensuration, the area of the ring = 4624.43 inches.

Then, $\frac{9116.8}{4624.43 \times 263} = 7.496$ inches nearly.

And if the ring is to be of a cylindrical form, find the diameter of a circle, (by Problem IX in Mensuration,) having the same area as the cross-section of the ring found.

Thus, suppose the ring, in the last example, be required to be cylindrical,—Required its cross-sectional diameter to equal 81.4 cwts., the diameter of the wheel being 16 feet.

$7.496 \times 8 = 59.968$ inches cross-sectional area of the ring found.

And $\sqrt{\frac{59.968 \times 452}{355}} = 8.73$ inches diameter nearly.

Or, as an approximate, multiply the required weight, in lbs., by 1.62; divide the product by the diameter of the wheel, in inches, and the square root of the quotient will be the diameter of the cross-section of the ring, in inches, nearly.

Thus, $\sqrt{\frac{9116.8 \times 1.62}{16 \times 12}} = 8.77$ inches.

Sometimes (for various reasons) it is necessary to have the fly-wheel upon a second mover; for instance, there is a 6 horse engine making 50 revolutions per minute, having a fly-wheel of 7 ft. diameter, and 9 cwt., but, by the rule, it ought to be 23.46 cwt. Now, a larger wheel cannot be got in, but the same may be put upon a second motion,—required the velocity that will increase its momentum equal to 23.46 cwt. on the first motion.

7 feet diameter = 21.9912 feet circumference, and 21.9912 × 50 revolutions = 1099.56 feet velocity.

Cwt. Velocity. Cwt. Veloci'y.

Then, as 9 : 1099.56 :: 23.46 : 2866.1864 ÷ 21.9912 = 130 revolutions per minute nearly.

To find the centrifugal force of a fly-wheel.

Rule.—Multiply the decimal .6136 by the diameter of the wheel in feet, and divide the product by the square of the time of one revolution; the quotient will be the centrifugal force when the weight of the body is 1.

Example.—Required the centrifugal force of a fly-wheel 15 feet diameter, and making 40 revolutions per minute, the weight of the ring being 3 tons,

60 ÷ 40 = 1.5, time of one revolution.

And $\frac{.6136 \times 15}{1.5^2} = 4.09 \times 3 = 12.27$ tons, the centrifugal force.

The centre of percussion in a fly-wheel, or wheels in general, is $\frac{3}{4}$ distant from the centre of suspension nearly.

NOTE.—The centrifugal force is that power or tendency which all revolving bodies have to burst, or fly asunder in a direct line.

And the centre of percussion in a revolving body is that point where the whole force or motion is collected, or that point which would strike any obstacle with the greatest effect.

THE GOVERNOR OR REGULATOR.

The length of pendulums given, to find the number of revolutions per minute.

RULE.—Divide 375 by the square root of the pendulum's length, and half the quotient will be the velocity required.

EXAMPLE.—What number of revolutions ought a governor to make per minute whose pendulums are 24 inches long?

$$\frac{375}{\sqrt{24}} = 76 \div 2 = 38 \text{ revolutions per minute.}$$

The revolutions per minute of a governor given, to find the length of pendulums.

RULE.—Divide 375 by twice the number of revolutions per minute, and the square of the quotient will be the length required.

EXAMPLE.—When the velocity of a governor is 38 revolutions per minute, what ought to be the length of pendulums?

$38 \times 2 = 76$, and $\frac{375}{76} = 4.93^2 = 24.3049$ inches nearly.

OF HIGH PRESSURE ENGINES.

High pressure engines, in general, (if in good condition,) will work when the force of the steam is about 4 lbs. per circular inch,—that is, 4 lbs. on each circular inch of the piston will overcome the resistance and friction of the engine itself, divested of machinery, &c. Hence the rule.

1. From the pressure in lbs. on each circular inch of the boiler deduct 4 lbs.; multiply the remainder by the square of the cylinder's diameter in inches, and by the velocity of the piston in feet per minute; divide the product by 33000, and the quotient will be the force of the engine expressed in horses' power.

EXAMPLE.—Suppose a cylinder 8 inches diameter, stroke 2 feet, making 45 revolutions per minute, or 180 feet, and steam 23.5 lbs. per circular inch, required the power.

$$23.5 - 4 = \frac{19.5 \times 8^2 \times 180}{33000} = 6.8 \text{ horses'}$$

power nearly.

2. Multiply 33000 by the number of horses' power required, and divide the product by the velocity of the piston in feet per minute, multiplied by the force of the steam in lbs. on each circular inch of the boiler, minus 4 lbs., and the square root of the quotient is the cylinder's diameter in inches.

EXAMPLE.—Required the diameter of the cylinder for an engine of 6.8 horses' power, when the stroke is 2 feet, and making 45 strokes per minute, the force of the steam being 23.5 lbs. per circular inch.

$$\frac{33000 \times 6.8}{180 \times 23.5 - 4} = \sqrt{64} = 8 \text{ inches diameter.}$$

NOTE.—There is always a resistance of steam on the piston of a high pressure or non-condensing engine equal to the pressure of the atmosphere, but this cannot be taken into account, unless we also take into account the pressure of the atmosphere upon the boiler.

MISCELLANIES.

Approximate rules for finding the weight of round, square, and rectangular beams, bars, &c., of cast and wrought iron.

RULE 1.—Multiply the square of the diameter in inches by the length in feet, and by 2.6 for wrought iron, or 2.48 for cast iron, and the product will be the weight in pounds avoirdupois nearly.

2.—Multiply the area of the cross section in inches by the length in feet, and by 3.32 for wrought iron, or 3.16 for cast iron, and the product will be the weight in pounds avoirdupois nearly.

EXAMPLE 1.—Required the weight of a round bar of wrought iron 14 feet long and $2\frac{1}{2}$ inches diameter.

$$2.5^2 \times 14 = 87.50 \times 2.6 = 227.5 \text{ lbs.}$$

EXAMPLE 2.—The length of a piece of cast iron is $9\frac{1}{2}$ feet, its breadth 7 inches, and thickness $2\frac{1}{4}$, required its weight.

$$2.25 \times 7 = 15.75 \times 9.5 = 149.625 \times 3.16 = 472.815 \text{ lbs.}$$

The dimensions of a cast iron ring being given, to find its weight nearly.

RULE.—Multiply the breadth of the ring added to the inner diameter by .0074, and that again by the breadth and by the thickness, and the product will be its weight in cwts. nearly.

EXAMPLE.—Required the weight of a ring whose dimensions are 8 feet 4 inches, interior diameter 5 inches broad and 4 inches thick.

Inches.

$$8 \text{ feet } 4 \text{ inches} = 100 + 5 = 105 \times .0074 = .777 \times 5 = 3.885 \times 4 = 15.52 \text{ cwts. nearly.}$$

To find the weight of any cast iron ball whose diameter is given.

RULE.—Multiply the cube of the diameter in inches by .1377, and the product will be the weight in avoirdupois pounds nearly.

EXAMPLE.—Required the weight of a ball 7 inches diameter.

$$7^3 = 343 \times .1377 = 47.2211 \text{ lbs.}$$

To find the diameter of a cast iron ball when the weight is given.

RULE.—Multiply the cube root of the weight in pounds by 1.936, and the product will be the diameter in inches nearly.

EXAMPLE.—Required the diameter of a ball that will weigh 64 pounds.

$$\sqrt[3]{64} = 4 \times 1.936 = 7.744 \text{ inches diameter.}$$

TABLE

Containing the weight of a square foot of copper and lead, in lbs. avoirdupois, from $\frac{1}{32}$ to $\frac{1}{2}$ an inch in thickness, advancing by $\frac{1}{32}$.

Thickness.	Copper.	Lead.
$\frac{1}{32}$	1.45	1.85
$\frac{1}{16}$	2.90	3.70
$\frac{3}{32}$	4.35	5.54
$\frac{1}{8}$	5.80	7.39
$\frac{5}{32}$ & $\frac{1}{32}$	7.26	9.24
$\frac{3}{16}$ & $\frac{1}{16}$	8.71	11.08
$\frac{7}{32}$ & $\frac{3}{32}$	10.16	12.93
$\frac{1}{4}$	11.61	14.77
$\frac{9}{32}$ & $\frac{1}{32}$	13.07	16.62
$\frac{5}{16}$ & $\frac{1}{16}$	14.52	18.47
$\frac{11}{32}$ & $\frac{3}{32}$	15.97	20.31
$\frac{3}{8}$	17.41	22.16
$\frac{13}{32}$ & $\frac{1}{32}$	18.87	24.00
$\frac{7}{16}$ & $\frac{1}{16}$	20.32	25.85
$\frac{15}{32}$ & $\frac{3}{32}$	21.77	27.70
$\frac{1}{2}$	23.22	29.55

TABLE

Of the weight of a square foot of sheet iron in lbs. avoirdupois, the thickness being the number on the wire gauge.—No. 1 is $\frac{5}{16}$ of an inch; No. 4, ¼; No. 11, ⅛, &c.

No. on wire gauge	1	2	3	4	5	6	7	8	9	10	11
Pounds avoir.....	12.5	12	11	10	9	8	7.5	7	6	5.68	5
No. on wire gauge	12	13	14	15	16	17	18	19	20	21	22
Pounds avoir.....	4.62	4.31	4	3.95	3	2.5	2.18	1.93	1.62	1.5	1.37

TABLE

Of the weight of a square foot of boiler plate iron, from ⅛ to 1 inch thick, in lbs. avoirdupois.

⅛	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	11/16	¾	13/16	⅞	15/16	1 in
5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40

TABLE

Of the weight of solid cylinders of cast iron, 12 inches long, in lbs. avoirdupois.

Dmr. Inch.	Weight in lbs.	Dmr. Inch.	Weight in lbs.	Dmr. Inch.	Weight in lbs.	Dmr. Inch.	Weight in lbs.	Dmr. Inch.	Weight in lbs.
$\frac{1}{16}$	1.394	$2\frac{1}{16}$	11.193	$3\frac{1}{16}$	30.364	$5\frac{3}{16}$	81.952	9	260.774
$\frac{1}{8}$	1.897	$2\frac{1}{8}$	12.548	$3\frac{1}{8}$	32.572	6	89.234	$9\frac{1}{2}$	223.704
1 in.	2.478	$2\frac{3}{16}$	13.981	$3\frac{3}{16}$	34.857	$6\frac{1}{4}$	96.825	10	247.872
$1\frac{1}{16}$	3.137	$2\frac{1}{4}$	15.492	$3\frac{1}{4}$	37.219	$6\frac{1}{2}$	104.726	$10\frac{1}{2}$	273.278
$1\frac{1}{8}$	3.873	$2\frac{5}{16}$	17.080	4	39.660	$6\frac{3}{4}$	112.936	11	299.925
$1\frac{3}{16}$	4.686	$2\frac{3}{8}$	18.745	$4\frac{1}{16}$	44.771	7	121.457	$11\frac{1}{2}$	327.811
$1\frac{1}{4}$	5.577	$2\frac{7}{16}$	20.488	$4\frac{1}{8}$	50.193	$7\frac{1}{4}$	130.287	12	356.935
$1\frac{5}{16}$	6.545	3	22.308	$4\frac{3}{16}$	55.926	$7\frac{1}{2}$	139.428	13	418.963
$1\frac{3}{8}$	7.591	$3\frac{1}{16}$	24.206	5	61.968	$7\frac{3}{4}$	148.878	14	485.830
$1\frac{7}{16}$	8.714	$3\frac{1}{8}$	26.181	$5\frac{1}{16}$	68.319	8	158.638	15	557.712
2	9.915	$3\frac{3}{16}$	28.234	$5\frac{1}{8}$	74.981	$8\frac{1}{2}$	179.087	16	634.552

Cubic inches of cast iron multiplied by .263 = lbs. avoirdupois.

Circular inches of cast iron multiplied by .2065 = lbs. avoirdupois.

TABLE

For finding the weight of malleable iron, copper, and lead pipes, 12 inches long, of various thicknesses, and any diameter required.

Thickness.	Mall. Iron.	Copper.	Lead.
$\frac{1}{16}$ of an inch.	.104	.121	.1539
$\frac{1}{8}$	.208	.2419	.3078
$\frac{3}{16}$	.3108	.3623	.4616
$\frac{1}{4}$	.414	.4838	.6155
$\frac{1}{4}$ & $\frac{1}{16}$	.518	.6047	.7694
$\frac{1}{4}$ & $\frac{1}{8}$	.621	.7258	.9232
$\frac{1}{4}$ & $\frac{3}{16}$	.725	.8466	1.0771
$\frac{1}{2}$	.828	.9678	1.231

RULE.—Multiply the circumference of the pipe in inches by the numbers opposite the thickness required, and by the length in feet; the product will be the weight in avoirdupois lbs. nearly.

EXAMPLE.—Required the weight of a copper pipe 12 feet long, 15 inches in circumference, $\frac{1}{4}$ and $\frac{1}{16}$ of an inch in thickness.

.7258 × 15 = 10,817 × 12 = 130.644 lbs. nearly.

TABLE

Containing the weight of wrought iron bars 12 inches long in lbs. avoirdupois.

Inch.	Round.	Square.	Inch.	Round.	Square.
1/16	.163	.208	2 1/2	16.32	20.80
1/8	.367	.467	2 5/8	18.00	22.89
3/16	.653	.830	2 3/4	19.76	25.12
1/4	1.02	1.30	2 7/8	21.59	27.46
5/16	1.47	1.87	3	23.52	29.92
3/8	2.00	2.55	3 1/4	27.60	35.12
1	2.61	3.32	3 1/2	32.00	40.80
1 1/16	3.31	4.21	3 3/4	36.72	46.72
1 1/8	4.08	5.20	4	41.76	53.12
1 3/16	4.94	6.28	4 1/4	47.25	60.00
1 1/4	5.88	7.48	4 1/2	52.93	67.24
1 5/16	6.90	8.78	4 3/4	58.92	74.95
1 3/8	8.00	10.20	5	65.28	83.20
1 7/16	9.18	11.68	5 1/4	72.00	91.56
2	10.44	13.28	5 1/2	79.04	100.48
2 1/16	11.80	15.00	5 3/4	86.36	109.82
2 1/4	13.23	16.81	6	94.08	119.68
2 3/8	14.73	18.74	7	128.00	163.20

TABLE

Of the proportional dimensions of 6-sided nuts for bolts, from 1/4 to 2 1/2 inches diameter.

Diameter of bolts	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Breadth of nuts	7/16	9/16	1	1 1/16	1 3/16	1 5/16	1 3/4	1 15/16	2 1/8
Breadth over the angles	3/4	1 1/8	1 1/8	1 3/8	1 5/16	1 1/8	2	2 1/4	2 7/16
Thickness	5/16	7/16	5/16	3/4	7/8	1	1 1/8	1 1/4	1 7/16

Diameter of bolts	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/4	2 1/2	
Breadth of nuts	2 5/16	2 1/2	2 11/16	2 7/8	3 1/16	3 1/4	3 3/8	4	
Breadth over the angles	2 11/16	2 7/8	3 1/4	3 5/16	3 1/2	3 3/4	4 5/16	4 5/8	
Thickness	1 5/16	1 1/16	1 1/16	2	2 1/8	2 1/4	2 3/8	2 3/4	

TABLE

Of the weight of flat bar iron, 12 inches long, in lbs. avoirdupois.

Thickness		⅛	3/16	¼	⅜	½	⅝	¾	⅞	1 inch
Breadth in inches.	¼	.21	.31	.42	.63					
	3/8	.31	.47	.63	.94	1.26	1.57			
	1	.42	.63	.84	1.26	1.68	2.10	2.52	2.94	
	1¼	.52	.78	1.05	1.57	2.10	2.62	3.15	3.67	4.20
	1⅜	.57	.86	1.18	1.73	2.31	2.88	3.46	4.04	4.62
	1½	.63	.94	1.26	1.89	2.52	3.15	3.78	4.41	5.04
	1⅝	.73	1.10	1.47	2.20	2.94	3.67	4.41	5.14	5.87
	2	.84	1.26	1.68	2.52	3.36	4.20	5.06	5.88	6.72
	2¼	.96	1.41	1.89	2.83	3.78	4.72	5.66	6.61	7.56
	2½	1.05	1.57	2.10	3.15	4.20	5.25	6.30	7 35	8.40
	2⅝	1.15	1.73	2.31	3.46	4.62	5.77	6.93	8.08	9.24
	3	1.26	1.89	2.52	3.78	5.04	6.30	7.56	8.82	10.08
	3¼	1.36	2.04	2.73	4.09	5.46	6.82	8.19	9,55	10.92
	3½	1.47	2.20	2.94	4.41	5.88	7.35	8.82	10.29	11.76
	3⅝	1.57	2.36	3.15	4.72	6.30	7.87	9.45	11.02	12.60
	4	1.68	2.52	3.36	5.04	6.72	8.40	10.08	11.76	13.44
	4½	1.89	2.83	3.78	5.67	7.56	9.45	11.34	13.23	15.12
	5	2.10	3.15	4.12	6.30	8.40	10.50	12.60	16.70	17.80
	6	2.52	3.78	5.04	7.56	10.08	12.60	15.12	17.64	20.16

Weight of a copper rod 12 inches long and 1 inch diameter = 3.039 lbs.

Weight of a brass rod 12 inches long and 1 inch diameter = 2.86 lbs.

TABLE

Of the specific gravity of water at different temperatures, that at 62° being taken as unity.

70°F.	.99913	52°F.	1.00076
68	.99936	50	1.00087
66	.99958	48	1.00095
64	.99980	46	1.00102
62	1.	44	1.00107
58	1.00035	42	1.00111
56	1.00050	40	1.00113
54	1.00064	38	1.00115

The difference of temperatures between 62° and 92° where water attains its greatest density, will vary th bulk of a gallon rather less than the third of a cubic inch.

TABLE

Of the weight of cast iron pipes 12 *inches long, in lbs. avoirdupois.*

Diam. of bore.	Thickness of Metal.						
	¼	⅜	½	⅝	¾	⅞	1
Inch.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1½	4.3	6.9	9.9				
2	5.5	8.8	12.3				
2½	.....	10.6	14.8	19.3			
3	.....	12.5	17.3	22.4			
3½	.....	14.4	19.8	25.5			
4	.....	.....	22.3	28.6	35.3		
4½	.....	.....	24.7	31.7	39		
5	.....	.....	27.2	34.8	42.7		
5½	.....	.....	29.7	37.7	46.4		
6	.....	.....	.....	41	50.2	59.6	
6½	.....	.....	.....	44.2	54	64	
7	.....	.....	... ..	47.2	57.2	68.3	
7½	.....	.....	.....	50.3	61.3	72.6	
8	.....	.....	.....	.....	65	77	89
8½	.....	.....	.....	.....	68.7	81.3	94.2
9	.....	.....	.....	.....	72.5	85.6	99.1
9½	.....	.....	.....	.....	76.2	90	104
10	.....	.....	.....	.....	79.9	94.3	109
10½	.....	.....	.....	.....	83.6	98.6	114
11	.....	.....	.....	.....	87.3	103	119
11½	.....	.....	.....	.....	91.1	107.3	124
12	.....	.....	.....	.....	94.8	111.7	129

NOTE.—The first column is the width of the pipes, expressed in inches and parts of an inch; and the remaining columns are the weights of the pipes, under the different thicknesses in which they are placed.

N.B.—Two flanges are generally reckoned equal to one foot of pipe.

TABLE

Of the weight of a square foot of millboard, in lbs. avoirdupois.

Thickness in inches.....	⅛	5/16	¼	5/16	⅜
Weight in lbs.....	.688	1.032	1.376	1.72	2.064

TABLE

Of the weight of cast iron balls, in pounds avoirdupois, from 1 to 12 inches diameter, and advancing by an eighth.

Inches.	Lbs. & Parts.	Inches.	Lbs. & Parts.	Inches.	Lbs. & Parts.
1	.14	4 3/8	14.76	8 1/8	84.56
1 1/8	.20	4 1/2	15.95	8 1/4	88.34
1 1/4	.27	5	17.12	8 3/8	92.24
1 3/8	.37	5 1/8	18.54	8 1/2	96.26
1 1/2	.47	5 1/4	19.93	9	100.39
1 5/8	.59	5 3/8	21.39	9 1/8	104.62
1 3/4	.74	5 1/2	22.91	9 1/4	108.98
1 7/8	.91	5 5/8	24.51	9 3/8	113.46
2	1.10	5 3/4	26.18	9 1/2	118.06
2 1/8	1.32	5 7/8	27.91	9 5/8	122.77
2 1/4	1.57	6	29.72	9 3/4	127.63
2 3/8	1.84	6 1/8	31.64	9 7/8	132.60
2 1/2	2.15	6 1/4	33.62	10	137.71
2 5/8	2.49	6 3/8	35.67	10 1/8	142.91
2 3/4	2.86	6 1/2	37.80	10 1/4	148.28
2 7/8	3.27	6 5/8	40.10	10 3/8	153.78
3	3.72	6 3/4	42.35	10 1/2	159.40
3 1/8	4.20	6 7/8	44.74	10 5/8	165.16
3 1/4	4.72	7	47.21	10 3/4	171.05
3 3/8	5.29	7 1/8	49.79	10 7/8	177.10
3 1/2	5.80	7 1/4	52.47	11	183.29
3 5/8	6.56	7 3/8	55.23	11 1/8	189.60
3 3/4	7.26	7 1/2	58.06	11 1/4	196.10
3 7/8	8.01	7 5/8	60.04	11 3/8	202.67
4	8.81	7 3/4	64.09	11 1/2	209.43
4 1/8	9.67	7 7/8	67.25	11 3/8	216.32
4 1/4	10.57	8	70.49	11 3/4	223.40
4 3/8	11.53	8 1/8	73.85	11 7/8	230.57
4 1/2	12.55	8 1/4	77.32	12	237.94
4 5/8	13.62	8 3/8	80.88		

TABLE

Containing some of the properties of various bodies.

Names of Bodies.	Melting and boiling points.	Contracts in cooling in parts of an inch, for each foot in length.	Expands in heating from 32 to 212 deg. of Fahrenheit the length being 1.00000.	Power of conducting heat.
Cast iron melts	17977°	.124	.00111	1.2
Wrought iron welding hot	12780	.137	.00122	1.1
Copper melts..	4587	.193	.00172	1.0
Brass melts ..	3807	.210	.00187	1.0
Steel red hot...	1077	.133	.00118	
Zinc melts ...	700	.329	.00294	
Mercury boils	660		.01851	
Lead melts ...	594	.319	.00286	2.5
Bismuth melts	476	.156	.00139	
Tin melts	442	.278	.00248	1.7
Water boils ...	212		.04002	

TABLE

Showing the expansion of water by heat.

Temperature.	Expansion.	Temperature.	Expansion.
12°F.	1.00236	122°.F	1.01116
22	1.00090	132	1.01367
32	1.00022	142	1.01638
42	1.	152	1.01934
52	1.00021	162	1.02245
62	1.00083	172	1.02575
72	1.00180	182	1.02916
82	1.00312	192	1.03265
92	1.00477	202	1.03634
102	1.00672	212	1.04012
112	1.00880		

Proportions of cement for cast iron.

In mixing cement for cast iron, put one ounce of sal ammoniac to each hundred weight of borings, and use it without allowing it to heat. Multiply the length of any joint in feet by the breadth in inches, by the thickness in eighths, and by .3; the product will be the weight of dry borings, in lbs. avoirdupois, required to make cement to fill that joint nearly.

TABLE

Of boiling points of water holding various proportions of salt in solution.

	Parts of Salt.	Degrees of Faht.	Degrees of Reau.	Degrees of Cent.
Saturated solution	36.37	2266	86.2	107.8
	33.34	224.9	85.7	107.2
	30.30	223.7	85.2	106.5
	27.28	222.5	84.7	105.8
	24.25	221.4	84.1	105.2
	21.22	220.2	83.6	104.6
	18.18	219	83	103.9
	15.15	217.9	82.6	103.3
	12.12	216.7	82.1	102.6
	9.09	215.5	81.6	102
	6.06	214.4	81.1	101.3
Sea water	3.03	213.2	80.5	100.7
Common water	0.00	212	80	100

To reduce any number of degrees of temperature on Fahrenheit's scale to the number of degrees of an equal temperature on Reaumer's scale; and also to the number of degrees of an equal temperature on the Centigrade scale or otherwise.

1.—*Above the freezing point.*

Any number of degrees of Fahrenheit minus 32, multiplied by 4, and divided by 9, = Reaumer.

$$\text{Thus, } 77^{\text{F.}} - 32 = 45, \text{ and } \frac{45 \times 4}{9} = 20^{\text{R.}}$$

See infra p. 93

$$\text{Or, } \frac{20 \times 9}{4} = 45, \text{ and } 45 + 32 = 77$$

2.—*Below the freezing point.*

Any number of degrees of Fahrenheit plus 32, multiplied by 4, and divided by 9, = Reaumer.

$$\text{Thus, } 22 + 32 = 54, \text{ and } \frac{54 \times 4}{9} = 24.$$

$$\text{Or, } \frac{24 \times 9}{4} = 54, \text{ and } 54 - 32 = 22.$$

3.—*Above the freezing point.*

Any number of degrees of Fahrenheit minus 32, multiplied by 5, and divided by 9, = Centigrade,

$$\text{Thus, } 167 - 32 = 135, \text{ and } \frac{135 \times 5}{9} = 75.$$

$$\text{Or, } \frac{75 \times 9}{5} = 135, \text{ and } 135 + 32 = 167.$$

4.—*Below the freezing point.*

Any number of degrees of Fahrenheit plus 32, multiplied by 5, and divided by 9, = Centigrade.

$$\text{Thus, } 13 + 32 = 45, \text{ and } \frac{45 \times 5}{9} = 25.$$

$$\text{Or, } \frac{25 \times 9}{5} = 45, \text{ and } 45 - 32 = 13.$$

TABLE

Showing the quantity and weight of a superficial foot of brick work, from half a brick to two and a half bricks in thickness.

Thickness by number.	Thickness in inches.	Number of bricks.	Weight in lbs. avoir.
½ brick	4½	4.58	40.23
1	9	9.15	80.37
1½	14	13.72	120.51
2	18½	18.3	160.74
2½	23½	22.875	200.93

NOTE.—The weight is independent of mortar.

1 Brick weighs 9lbs. avoirdupois nearly ; $12\frac{1}{2}$ = 1 cwt., and 250 = 1 ton.

TABLE

Of the specific gravities of those bodies chiefly used in machinery, building, &c., showing, in avoirdupois ounces and pounds, the weight of a cubic foot of each body; also the weight of a cubic inch, and the number of cubic inches in a pound, with multipliers to each, for finding the weight when the dimensions are given.

Names of Bodies.	Weight of a Cubic Foot		Weight of a Cubic In.	No. of Cubic inches in a Pound.	Multipliers.
	oz.	*lb.*	*oz.*		
Copper, cast.....	8788	549.25	5.086	3.146	.3178
Copper, sheet.....	8915	557.18	5.159	3.103	.3225
Brass, cast.....	8396	524.75	4.852	3.293	.3037
Iron, cast.....	7271	454.43	4.203	3.802	.263
Iron, bar.....	7631	476.93	4.410	3.623	.276
Lead.....	11344	709.00	6.456	2.437	.4103
Steel, soft.....	7833	489.56	4.527	3.530	.2833
Steel, hard.....	7816	488.50	4.517	3.537	.2827
Zinc, cast.....	7190	449.37	4.156	3.845	.26
Tin, cast.....	7292	455.75	4.215	3.790	.2636
Bismuth.....	9880	619.50	5 710	2.789	.3585
Gun metal.....	8784	549.00	5.0775	3.147	.3177
Sand.....	1520	95.00	.8785	18.190	.055
Coal.....	1250	78.12	.7225	22.120	.0452
Brick	2000	125.00	1.156	13.824	.0723
Stone, paving.....	2416	151.00	1.396	11.443	.0873
Slate	2672	167.00	1.544	10.347	.0967
Marble.....	2742	171.37	1.585	10.083	.0991
White Lead	3160	197.50	1.826	8.750	.1143
Glass.....	2880	180.00	1.664	9.600	.1042
Tallow	945	59.06	.5462	29.258	.0342
Cork.....	240	15.00	.138	115.200	.0087
Larch	544	34.00	.315	50.823	.0197
Elm.....	556	34.75	.321	49.726	.0201
Pine, pitch.....	660	41.25	.382	41.890	.024
Beech	696	43.50	.403	39.724	.0252
Teak	745	46.56	.431	37.113	.027
Ash.....	760	47.50	.440	36.370	.0275
Mahogany	852	53.25	.493	32.449	.0308
Oak.....	970	60.62	.561	28.505	.0351
Oil of Turpentine	870	54.37	.503	31.771	.0315
Olive Oil	915	57.18	.529	30.220	.0331
Linseed Oil,.....	932	58.25	.539	29.665	.0337
Spirits, proof.....	927	57.93	.536	29.828	.03352
Water, distilled..	1000	62.50	.578	27.648	.03617
Water, sea.....	1028	64.25	.594	26.894	.0372
Tar	1015	63.43	.587	27.242	.0367
Vinegar	1026	64.12	.593	26.949	.037
Mercury	13568	848.00	7.851	2.037	.4908

The 1st, 2d, 3d, and 4th columns require no farther explanation than the titles they bear; the fifth column is to find the weight of any number of cubic inches, in avoirdupois pounds, of any of the different bodies required.

EXAMPLE 1.—Suppose a piece of cast iron to be $56\frac{3}{4}$ inches long, $16\frac{1}{2}$ inches broad, and $\frac{3}{4}$ of an inch in thickness, required its weight.

$56.75 \times 16.5 \times .75 = 702.28125$ cubic inches.
$\times .263 = 184.7$ lbs. nearly.

EXAMPLE 2.—Required the weight of an imperial gallon of proof spirits.

$277.274 \times .03352 = 9.294$ lbs. nearly.

EXAMPLE 3.—Required the thickness of metal for a concave copper ball, 8 inches diameter without, so as to sink to its centre in common water.

$8^3 \times .5236 = 268.0832$ cubic inches in the ball, $\div 2 = 134.0416$ cubic inches to be immersed, or cubic inches of water to be removed, —Then $134.0416 \times .578$ weight of a cubic inch of water $= 77.4760448$ ounces weight of water displaced, or, the weight of the copper ball; which divide by 5.159, the weight of a cubic inch of copper, $= 15.0176$ cubic inches of copper in the ball.

Again, $8^2 \times .7854 \times 4 = 202.0624$ square inches, the superficies of the ball; and $15.0176 \div 202.0624 = .0743$ inches, the required thickness of the copper nearly.

EXAMPLE 4.—Required the weight necessary to counterpoise a float of paving stone proper for a steam-engine boiler, &c., the float being 14 inches diameter and $2\frac{1}{2}$ inches thick.

$14^2 \times .7854 \times 2.5 = 384.846$ cubic inches.
Then $384.846 \times .0873 = 33.597$ lbs. the weight of the stone. And, $384.846 \times .03617 = 13.919$ weight of water displaced; then, $33.597 - 9 = 19.678$ lbs. the counterpoise required.

APPENDIX;

CONTAINING

CIRCUMFERENCES, SQUARES, CUBES, AND AREAS OF CIRCLES;

SUPERFICIES AND SOLIDITIES OF SPHERES, &c.

APPENDIX.

TABLE

Containing the circumferences, squares, cubes, and areas of circles, from 1 *to* 100, *advancing by a tenth.*

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
1	3.1416	1	1	.7854
.1	3.4557	1.21	1.331	.9503
.2	3.7699	1.44	1.728	1.1309
.3	4.0840	1.69	2.197	1.3273
.4	4.3982	1.96	2.744	1.5393
.5	4.7124	2.25	3.375	1.7671
.6	5.0265	2.56	4.096	2.0106
.7	5.3407	2.89	4.913	2.2698
.8	5.6548	3.24	5.832	2.5446
.9	5.9690	3.61	6.859	2.8352
2	6.2832	4	8	3.1416
.1	6.5973	4.41	9.261	3.4636
.2	6.9115	4.84	10.648	3.8013
.3	7.2256	5.29	12.167	4.1547
.4	7.5398	5.76	13.824	4.5239
.5	7.8540	6.25	15.625	4.9087
.6	8.1681	6.76	17.576	5.3093
.7	8.4823	7.29	19.683	5.7255
.8	8.7964	7.84	21.952	6.1575
.9	9.1106	8.41	24.389	6.6052
3	9.4248	9	27	7.0686
.1	9.7389	9.61	29.791	7.5476
.2	10.0531	10.24	32.768	8.0424
.3	10.3672	10.89	35.937	8.5530
.4	10.6814	11.56	39.304	9.0792
.5	10.9956	12.25	42.875	9.6211
.6	11.3097	12.96	46.656	10.1787
.7	11.6239	13.69	50.653	10.7521
.8	11.9380	14.44	54.872	11.3411
.9	12.2522	15.21	59.319	11.9459
4	12.5664	16	64	12.5664
.1	12.8805	16.81	68.921	13.2025
.2	13.1947	17.64	74.088	13.8544
.3	13.5088	18.49	79.507	14.5220
.4	13.8230	19.36	85.184	15.2053
.5	14.1372	20.25	91.125	15.9043
.6	14.4513	21.16	97.336	16.6190
.7	14.7655	22.09	103.823	17.3494
.8	15.0796	23.04	110.592	18.0956
.9	15.3938	24.01	117.649	18.8574

Diam.	Circum.	Square.	Cube.	Area.
5	15.7080	25	125	19.6350
.1	16.0221	26.01	132.651	20.4282
.2	16.3363	27 04	140.608	21.2372
.3	16.6504	28.09	148.877	22.0618
.4	16.9646	29.16	157.464	22.9022
.5	17.2788	30.25	166.375	23.7583
.6	17.5929	31.36	175.616	24.6301
.7	17.9071	32.49	185.193	25.5176
.8	18.2212	33.64	195.112	26.4208
.9	18.5354	34.81	205.379	27.3397
6	18.8496	36	216	28.2744
.1	19.1637	37.21	226.981	29.2247
.2	19.4779	38.44	238.328	30.1907
.3	19.7920	39.69	250.047	31.1725
.4	20.1062	40.96	262.144	32.1699
.5	20.4204	42 25	274.625	33.1831
.6	20.7345	43.56	287.496	34.2120
.7	21.0487	44.89	300.763	35.2566
.8	21.3628	46.24	314.432	36.3168
.9	21.6770	47.61	328 509	37.3928
7	21.9912	49	343	38.4846
.1	22.3053	50.41	357.911	39.5920
.2	22 6195	51.84	373.248	40.7151
.3	22.9336	53.29	389.017	41.8539
.4	23 2478	54.76	405.224	43.0085
.5	23.5620	56.25	421.875	44.1787
.6	23.8761	57.76	438.976	45.3647
.7	24.1903	59.29	456 533	46.5663
.8	24.5044	60.84	474.552	47.7837
.9	24.8186	62.41	493.039	49.0168
8	25.1328	64	512	50.2656
.1	25.4469	65.61	531.441	51.5300
.2	25.7611	67.24	551.368	52.8102
.3	26.0752	68.89	571.787	54.1062
.4	26.3894	70.56	592.704	55.4178
.5	26.7036	72 25	614.125	56.7451
.6	27.0177	73.96	636.056	58.0881
.7	27.3319	75.69	658.503	59.4469
.8	27.6460	77.44	681.472	60.8213
.9	27.9602	79.21	704.969	62.2115
9	28.2744	81	729	63.6174
.1	28.5885	82.81	753.571	65.0389
.2	28.9027	84.64	778.688	66.4762
.3	29.2168	86.49	804.357	67.9292
.4	29.5310	88.36	830.584	69.3979
.5	29.8452	90.25	857.375	70.8823
.6	30.1593	92.16	884.736	72.3824
.7	30.4735	94.09	912.673	73.8982
.8	30.7876	96.04	941.192	75.4298
.9	31.1018	98.01	970.299	76.9770

Diam.	Circum.	Square.	Cube.	Area.
10	31 4160	100	1000	78.5400
.1	31.7301	102.01	1030.301	80.1186
.2	32.0443	104.04	1061.208	81.7130
.3	32.3580	106.09	1092.727	83.3230
.4	32.6726	108.16	1124.864	84.9488
.5	32.9868	110.25	1157.625	86.5903
.6	33.3009	112.36	1191.016	88.2475
.7	33.6151	114.49	1225.043	89.9204
.8	33.9292	116.64	1259.712	91.6090
.9	34.2434	118.81	1295.029	93.3133
11	34.5576	121	1331	95.0334
.1	34.8717	123.21	1367.631	96.7691
.2	35.1859	125.44	1404.928	98.5205
.3	35.5010	127.69	1442.897	100.2877
.4	35.8142	129.96	1481.544	102.0705
.5	36.1284	132.25	1520.875	103.8691
.6	36.4425	134.56	1560.896	105.6834
.7	36.7567	136.89	1601.613	107.5134
.8	37.0708	139.24	1643.032	109.3590
.9	37.3840	141.61	1685.159	111.2204
12	37.6992	144	1728	113.0976
.1	38.0133	146.41	1771.561	114.9904
.2	38.3275	148 84	1815.848	116.8989
.3	38.6416	151.29	1860.867	118.8231
.4	38.9558	153.76	1906.624	120.7631
.5	39.2700	156.25	1953.125	122.7187
.6	39.5841	158.76	2000.376	124.6901
.7	39.8983	161.29	2048.383	126.6771
.8	40.2124	163.84	2097.152	128.6799
.9	40.5266	166.41	2146.689	130.6984
13	40.8408	169	2197	132.7326
.1	41.1549	171.61	2248.091	134.7824
.2	41.4691	174.24	2299.968	136.8480
.3	41.7832	176.89	2352.637	138.9294
.4	42.0974	179.56	2406.104	141.0264
.5	42.4116	182.25	2460.375	143.1391
.6	42.7257	184 96	2515.456	145.2675
.7	43.0399	187.69	2571.353	147.4117
.8	43.3540	190.44	2628.072	149.5715
.9	43.6682	193.21	2685.619	151.7471
14	43.9824	196	2744	153.9384
.1	44.2965	198.81	2803.221	156.1453
.2	44.6107	201.64	2863.288	158.3680
.3	44.9248	204.49	2924.207	160.6064
.4	45.2390	207.36	2985.984	162.8605
.5	45.5532	210.25	3048.625	165.1303
.6	45.8673	213 16	3112.136	167.4158
.7	46.1815	216.09	3176.523	169.7170
.8	46.4956	219 04	3241.792	172.0340
.9	46.8098	222.01	3307.949	174.3666

APPENDIX.

TABLE

Containing the circumferences, squares, cubes, and areas of circles, from 1 *to* 100, *advancing by a tenth.*

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
1	3.1416	1	1	.7854
.1	3.4557	1.21	1.331	.9503
.2	3.7699	1.44	1.728	1.1309
.3	4.0840	1.69	2.197	1.3273
.4	4.3982	1.96	2.744	1.5393
.5	4.7124	2.25	3.375	1.7671
.6	5.0265	2.56	4.096	2.0106
.7	5.3407	2.89	4.913	2.2698
.8	5.6548	3.24	5.832	2.5446
.9	5.9690	3.61	6.859	2.8352
2	6.2832	4	8	3.1416
.1	6.5973	4.41	9.261	3.4636
.2	6.9115	4.84	10.648	3.8013
.3	7.2256	5.29	12.167	4.1547
.4	7.5398	5.76	13.824	4.5239
.5	7.8540	6.25	15.625	4.9087
.6	8.1681	6.76	17.576	5.3093
.7	8.4823	7.29	19.683	5.7255
.8	8.7964	7.84	21.952	6.1575
.9	9.1106	8.41	24.389	6.6052
3	9.4248	9	27	7.0686
.1	9.7389	9.61	29.791	7.5476
.2	10.0531	10.24	32.768	8.0424
.3	10.3672	10.89	35.937	8.5530
.4	10.6814	11.56	39.304	9.0792
.5	10.9956	12.25	42.875	9.6211
.6	11.3097	12.96	46.656	10.1787
.7	11.6239	13.69	50.653	10.7521
.8	11.9380	14.44	54.872	11.3411
.9	12.2522	15.21	59.319	11.9459
4	12.5664	16	64	12.5664
.1	12.8805	16.81	68.921	13.2025
.2	13.1947	17.64	74.088	13.8544
.3	13.5088	18.49	79.507	14.5220
.4	13.8230	19.36	85.184	15.2053
.5	14.1372	20.25	91.125	15.9043
.6	14.4513	21.16	97.336	16.6190
.7	14.7655	22.09	103.823	17.3494
.8	15.0796	23.04	110.592	18.0956
.9	15.3938	24.01	117.649	18.8574

Diam.	Circum.	Square.	Cube.	Area.
25	78.5400	625	15625	490.8750
.1	78.8541	630.01	15813.251	494.8098
.2	79.1683	635.04	16003.008	498.7604
.3	79.4824	640.09	16194.277	502.7266
.4	79.7966	645.16	16387.064	506.7086
.5	80.8108	650.25	16581.375	510.7063
.6	80.4249	655.36	16777.216	514.7196
.7	80.7391	660.49	16974.593	518.7488
.8	81.0532	665.64	17173.512	522.7936
.9	81.3674	670.81	17373.979	526.8541
26	81.6816	676	17576	530.9304
.1	81.9976	681.21	17779.581	535.0223
.2	82.3099	686.44	17984.728	539.1299
.3	82.6240	691.69	18191.447	543.2533
.4	82.9382	696.96	18399.744	547.3923
.5	83.2524	702.25	18609.625	551.5471
.6	83.5665	707 56	18821.096	555.7176
.7	83.8807	712.89	19034.163	559.9038
.8	84.1948	718 24	19248.832	564.1056
.9	84 5090	723 61	19465.109	568.3232
27	84.8232	729	19683	572.5566
.1	85.1373	734.41	19902.511	576.8056
.2	85.4515	739.84	20123.648	581.0703
.3	85.7656	745.29	20346.417	585 3507
.4	86.0798	750.76	20570.824	589.6469
.5	86.3940	756 25	20796.875	593.9587
.6	86.7081	761.76	21024.576	598.2863
.7	87.0223	767.29	21253.933	602.6295
.8	87.3364	772.84	21484.952	606.9885
.9	87.6506	778.41	21717.639	611.3632
28	87.9648	784	21952	615.7536
.1	88.2789	789.61	22188.041	620.1596
.2	88.5931	795.24	22425.768	624.5814
.3	88.9072	800.89	22665.187	629.0190
.4	89.2214	806.56	22906.304	633.4722
.5	89.5356	812.25	23149.125	637.9411
.6	89.8497	817.96	23393.656	642.4257
.7	90.1639	823.69	23639.903	646.9261
.8	90.4780	829.44	23887.872	651.4421
.9	90.7922	835.21	24137.569	655.9739
29	91.1064	841	24389	660.5214
.1	91.4205	846.81	24642.171	665.0845
.2	91.7347	852.64	24897.088	669.6634
.3	92.0488	858.49	25153.757	674.2580
.4	92.3630	864.36	25412.184	678.8683
.5	92.6772	870.25	25672.375	683.4943
.6	92.9913	876.16	25934.336	688.1360
.7	93.3055	882.09	26198.073	692.7934
.8	93.6196	888.04	26463.592	697.4666
.9	93.9338	894.01	26730.899	702.1554

Diam.	Circum.	Square.	Cube.	Area.
30	94.2480	900	27000	706.8600
.1	94.5621	906.01	27270.901	711.5802
.2	94.8763	912.04	27543.608	716.3162
.3	95.1904	918.09	27818.127	721.0678
.4	95.5046	924.16	28094.464	725.8352
.5	95.8188	930.25	28372.625	730.6183
.6	96.1329	936.36	28652.616	735.4171
.7	96.4471	942.49	28934.443	740.2316
.8	96.7612	948.64	29218.112	745.0618
.9	97.0754	954.81	29503.629	749.9077
31	97.3896	961	29791	754.7694
.1	97.7037	967.21	30080.231	759.6467
.2	98.0179	973.44	30371.328	764.5397
.3	98.3320	979.69	30664.297	769.4485
.4	98.6452	985.96	30959.144	774.3729
.5	98.9604	992.25	31255.875	779.3131
.6	99.2745	998.56	31554.496	784.2689
.7	99.5887	1004.89	31855.013	789.2406
.8	99.9028	1011.24	32157.432	794.2278
.9	100.2170	1017.61	32461.759	799.2308
32	100.5312	1024	32768	804.2496
.1	100.8453	1030.41	33076.161	809.2840
.2	101.1595	1036.84	33386.248	814.3341
.3	101.4736	1043 29	33698.267	819.3999
.4	101.7878	1049.76	34012.224	824.4815
.5	102.1020	1056.25	34328.125	829.5787
.6	102.4161	1062.76	34645.976	834.6917
.7	102.7303	1069.29	34965.783	839.8203
.8	103.0444	1075.84	35287.552	844.9647
.9	103.3586	1082.41	35611.289	850.1248
33	103.6728	1089	35937	855.3006
.1	103.9869	1095.61	36264.691	860.4920
.2	104.3011	1102.24	36594.368	865.6992
.3	104.6151	1108.89	36926.037	870.9222
.4	104.9294	1115.56	37259.704	876.1608
.5	105.2436	1122.25	37595.375	881.4151
.6	105.5577	1128.96	37933.056	886.6851
.7	105.8719	1135.69	38272.753	891.9709
.8	106.1860	1142.44	38614.472	897.2723
.9	106.5002	1149.21	38958.219	902.5895
34	106.8144	1156	39304	907.9224
.1	107.1285	1162.81	39651.821	913.2709
.2	107.4272	1169.64	40001.688	918.6352
.3	107.7568	1176.49	40353.607	924.0115
.4	108.0710	1183.36	40707.584	929.4109
.5	108.3852	1190.25	41063.625	934.8223
.6	108.6993	1197.16	41421.736	940.2494
.7	109.0352	1204.09	41781.923	945.6922
.8	109.3076	1211.04	42144.192	951.1508
.9	109.6418	1218.01	42508.549	956.6250

Diam.	Circum.	Square.	Cube.	Area.
35	109.9560	1225	42875	962.1150
.1	110.2701	1232.01	43243.551	967.6206
.2	110.5843	1239.04	43614.208	973.1420
.3	110.8984	1246.09	43986.977	978.6790
.4	111.2126	1253.16	44361.864	984.2318
.5	111.5268	1260.25	44738.875	989.8003
.6	111.8409	1267.36	45118.016	995.3845
.7	112.1551	1274.49	45499.293	1000.9843
.8	112.4692	1281.64	45882.712	1006.6000
.9	112.7834	1288.81	46268.279	1012.2313
36	113.0976	1296	46656	1017.8784
.1	113.4117	1303.21	47045.831	1023.5411
.2	113.7259	1310.44	47437.928	1029.2195
.3	114.0400	1317.69	47832.147	1034.9131
.4	114.3542	1324.96	48228.544	1040.6235
.5	114.6684	1332.25	48627.125	1046.3491
.6	114.9825	1339.56	49027.896	1052.0904
.7	115.2967	1346.89	49430.863	1057.8474
.8	115.6108	1354.24	49836.032	1063.6200
.9	115.9250	1361.61	50243.409	1069.4084
37	116.2392	1369	50653	1075.2126
.1	116.5533	1376.41	51064.811	1081.0324
.2	116.8675	1383.84	51478.848	1086.8679
.3	117.1816	1391.29	51895.117	1092.7191
.4	117.4958	1398.76	52313.624	1098.5862
.5	117.8100	1406.25	52734.375	1104.4687
.6	118.1241	1413.76	53157.376	1110.3671
.7	118.4383	1421.29	53582.633	1116.2811
.8	118.7524	1428.84	54010.152	1122.2109
.9	119.0666	1436.41	54439.939	1128.1564
38	119.3808	1444	54872	1134.1176
.1	119.6949	1451.61	55306.341	1140.0946
.2	120.0091	1459.24	55742.968	1146.0870
.3	120.3232	1466.89	56181.887	1152.0954
.4	120.6374	1474.56	56623.104	1158.1194
.5	120.9516	1482.25	57066.625	1164.1591
.6	121.2657	1489.96	57512.456	1170.2145
.7	121.5799	1497.69	57960.603	1176.2857
.8	121.8940	1505.44	58411.072	1182.3725
.9	122.2082	1513.21	58863.869	1188.4651
39	122.5224	1521	59319	1294.5394
.1	122.8365	1528.81	59776.471	1200.7273
.2	123.1507	1536.64	60236.288	1206.8770
.3	123.4648	1544.49	60698.457	1213.0424
.4	123.7790	1552.36	61162.984	1219.2243
.5	124.0932	1560.25	61629.875	1225.4203
.6	124.4073	1568.16	62099.136	1231.6328
.7	124.7215	1576.09	62570.773	1237.8610
.8	125.0356	1584.04	63044.792	1244.1210
.9	125.3498	1592.01	63521.199	1250.3646

Diam.	Circum.	Square.	Cube.	Area.
40	125.6640	1600	64000	1256.6400
.1	125.9781	1608.01	64481.201	1262.9310
.2	126.2923	1616.04	64964.808	1269.2388
.3	126.6064	1624.09	65450.827	1275.5602
.4	126.9206	1632.16	65939 264	1281.8984
.5	127.2348	1640.25	66430.125	1288.2523
.6	127.5489	1648.36	66923.416	1294.6219
.7	127.8631	1656 49	67419.143	1301.0071
.8	128.1772	1664.64	67917.312	1307.4082
.9	128.4914	1672.81	68417.929	1313.8249
41	128.8056	1681	68921	1320.2574
.1	129.1197	1689.21	69426.531	1326.7055
.2	129.4323	1697.44	69934.528	1333.1693
.3	129.7480	1705.69	70444.997	1339.6489
.4	130.0622	1713.96	70957.944	1346.1441
.5	130.3764	1722.25	71473.375	1352.6551
.6	130.6905	1730.56	71991.296	1359.1818
.7	131.0047	1738.89	72511.713	1365.7242
.8	131.3188	1747.24	73034.632	1372.2822
.9	131.6320	1755.61	73560.059	1378.8560
42	131.9472	1764	74088	1385.4456
.1	132.2613	1772.41	74618.461	1392.0508
.2	132.5755	1780.84	75151.448	1398.6717
.3	132.8896	1789.29	75686.967	1405.3083
.4	133.2038	1797.76	76225.024	1411.9607
.5	133.5180	1806.25	76765.625	1418.6287
.6	133.8321	1814.76	77308.776	1425.3125
.7	134.1463	1823.29	77854.483	1432.0119
.8	134.4604	1831.84	78402.752	1438.7271
.9	134.7746	1840.41	78958.589	1445.4580
43	135.0888	1849	79507	1452.2046
.1	135.4029	1857.61	80062.991	1458.9668
.2	135.7171	1866.24	80621.568	1465.7448
.3	136.0332	1874.89	81182.737	1472.5385
.4	136.3454	1883.56	81746.504	1479.3480
.5	136.6596	1892.25	82312.875	1486.1731
.6	136.9737	1900.96	82881.856	1493.0139
.7	137.2879	1909.69	83453.453	1459.8705
.8	137.6020	1918.44	84027.672	1506.7427
.9	137.9162	1927.21	84604.519	1513.6287
44	138 2304	1936	85184	1520.5344
.1	138 5445	1944.81	85766.121	1527.4537
.2	138.8587	1953.64	86350.888	1534.3888
.3	139.1728	1962.49	86938 307	1541.3396
.4	139.4870	1971.36	87528.384	1548.3061
.5	139.8012	1980.25	88121.125	1555.2883
.6	140.1153	1989.16	88716.536	1562.2862
.7	140.4295	1998.09	89314.623	1569.2998
.8	140.7436	2007.04	89915.392	1576.3292
.9	141.0578	2016.01	90518.849	1583.3742

Diam.	Circum.	Square.	Cube.	Area.
45	141.3720	2025	91125	1590.4350
.1	141.6861	2034.01	91733.851	1597.5114
.2	142.0003	2043.04	92345.408	1604.6036
.3	142.3144	2052.09	92959.677	1611.7114
.4	142.6286	2061.16	93576.664	1618.8350
.5	142.9428	2070.25	94196.375	1625.9743
.6	143.2569	2079.36	94818.816	1633.1293
.7	143.5711	2088.49	95443.993	1640.3020
.8	143.8852	2097.64	96071.912	1647.4864
.9	144.1994	2106.81	96702.579	1654.6885
46	144 5136	2116	97336	1661.9064
.1	144.8277	2125.21	97972.181	1669.1399
.2	145.1419	2134.44	98611.128	1676.3891
.3	145.4560	2143.69	99252.847	1683.6541
.4	145.7702	2152.96	99897.344	1690.9347
.5	146.0844	2162.25	100544 625	1698 2311
.6	146.3985	2171.56	101194.696	1705.5432
.7	146.7127	2180.89	101847.563	1712.8710
.8	147.0268	2190.24	102503.232	1720.2144
.9	147.3410	2199.61	103161.709	1727.5736
47	147.6552	2209	103823	1734.9486
.1	147.9693	2218.41	104487.111	1742.3392
.2	148.2835	2227.84	105154.048	1749.7455
.3	148.5976	2237.29	105823.817	1757.1675
.4	148.9118	2246.76	106496.424	1764.6045
.5	149.2260	2256.25	107171.875	1772.0587
.6	149.5361	2265.76	107850.176	1779.5279
.7	149.8543	2275.29	108531.333	1787.0127
.8	150.1684	2284.84	109215.352	1794.5133
.9	150.4826	2294.41	109902.239	1802.0296
48	150.7968	2304	110592	1809.5616
.1	151.1109	2313.61	111284.641	1817.1092
.2	151.4251	2323.24	111980.168	1824.6726
.3	151.7392	2332.89	112678.587	1832.2518
.4	152.0534	2342.56	113379.904	1839.8466
.5	152.3676	2352.25	114084.125	1847.4571
.6	152.6817	2361.96	114791.256	1855.0833
.7	152.9959	2371.69	115501.303	1862.7253
.8	153.3100	2381.44	116214.272	1870.3829
.9	153.6242	2391.21	116930.169	1878.0563
49	153.9384	2401	117649	1885.7454
.1	154.2525	2410.81	118370.771	1893.4501
.2	154.5667	2420.64	119095.488	1901.1706
.3	154.8808	2430.49	119823.157	1908.9068
.4	155.1950	2440.36	120553.784	1916.6587
.5	155.5092	2450.25	121287.375	1924.4263
.6	155.8233	2460.16	122023.936	1932.2096
.7	156.1375	2470.09	122763.473	1940.0086
.8	156.4516	2480.04	123505.992	1947.8234
.9	156.7558	2490.01	124251.499	1955.6538

Diam.	Circum.	Square.	Cube.	Area.
50	157.0800	2500	125000	1963.5000
.1	157.3941	2510.01	125751.501	1971.3618
.2	157.7083	2520.04	126506.008	1979.2394
.3	158.0224	2530.09	127263.527	1987.1326
.4	158.3366	2540.16	128024.064	1995.0416
.5	158 6508	2550.25	128787.625	2002.9663
.6	158.9649	2560.36	129554.216	2010.9067
.7	159.2791	2570.49	130323.843	2018.8628
.8	159.5932	2580.64	131096.512	2026.8346
.9	159.9074	2590.81	131872.229	2034.8770
51	160.2216	2601	132651	2042.8254
.1	160.5357	2611.21	133432.831	2050.8443
.2	160 8499	2621.44	134217.728	2058.8784
.3	161.1640	2631.69	135005.697	2066.9293
.4	161.4782	2641.96	135796.744	2074.9953
.5	161.7924	2652.25	136590.875	2083.0771
.6	162.1065	2662.56	137388.096	2091.1746
.7	162.4207	2672.89	138188.413	2099.2878
.8	162.7348	2683.24	138991.832	2107.4166
.9	163.0490	2693.61	139798.359	2115.5612
52	163.3632	2704	140608	2123.7216
.1	163.6773	2714.41	141420.761	2131.8976
.2	163.9935	2724.84	142236.648	2140.0893
.3	164.3056	2735.29	143055.667	2148.2967
.4	164.6198	2745.76	143877.824	2156.5199
.5	164.9340	2756.25	144703.125	2164.7587
.6	165.2481	2766.76	145531.576	2173.0133
.7	165.5623	2777.29	146363.183	2181.2835
.8	165.8764	2787.84	147197.952	2189.5695
.9	166.1906	2798.41	148035.889	2197.8712
53	166.5048	2809	148877	2206.1886
.1	166.8189	2819.61	149721.291	2214.5216
.2	167.1331	2830.24	150568.768	2222.8704
.3	167.4472	2840.89	151419 437	2231.2350
.4	167.7614	2851.56	152273.304	2239.6152
.5	168.0756	2862.25	153130.375	2248.0111
.6	168 3897	2872.96	153990.656	2256.4227
.7	168.7049	2883.69	154854.153	2264.8701
.8	169.0180	2894.44	155720.872	2273.2931
.9	169.3322	2905.21	156590.819	2281.7519
54	169.6464	2916	157464	2290.2264
.1	169.9605	2926.81	158340.421	2298.7165
.2	170.2747	2937.64	159220.088	2307.2224
.3	170.5888	2948.49	160103 007	2315.7440
.4	170.9030	2959.36	160989.184	2324 2813
.5	171.2172	2970.25	161878.625	2332.8343
.6	171.5313	2981.16	162771.336	2341.4030
.7	171.8455	2992.09	163667.323	2349.9874
.8	172.1596	3003 04	164566.592	2358.5876
.9	172.4738	3014.01	165469.149	2367.2034

Diam.	Circum.	Square.	Cube.	Area.
55	172.7880	3025	166375	2375.8350
.1	173.1021	3036.01	167284.151	2384.4822
.2	173.4163	3047.04	168196.608	2393.1452
.3	173.7304	3058.09	169112.377	2401.8238
.4	174.0446	3069.16	170031.464	2410.5182
.5	174.3588	3080.25	170953.875	2419.2283
.6	174.6729	3091.36	171879.616	2427.9541
.7	174.9771	3102.49	172808.693	2436.6956
.8	175.3092	3113.64	173741.112	2445.4528
.9	175.6154	3124.81	174676.879	2454.2257
56	175.9296	3136	175616	2463.0144
.1	176.2437	3147.21	176558.481	2471.8187
.2	176 5579	3158.44	177504.328	2480.6387
.3	176.8720	3169.69	178453.547	2489.4745
.4	177.1862	3180.96	179406.144	2498 3259
.5	177.5004	3192.25	180362.125	2507.1931
.6	177.8145	3203.56	181321.496	2516.0760
.7	178.1287	3214.89	182284.263	2524.9736
.8	178.4428	3226.24	183250.432	2533.8888
.9	178.7570	3237.61	184220.009	2542.8188
57	179.0712	3249	185193	2551.7646
.1	179.3853	3260.41	186169.411	2560.7260
.2	179.6995	3271 84	187149.248	2569.7031
.3	180.0136	3283.29	188132.517	2578.6959
.4	180.3278	3294.76	189119.224	2587.7045
.5	180.6420	3306.25	190109.375	2596.7287
.6	180.9561	3317.76	191102.976	2605.7687
.7	181.2803	3329.29	192100.033	2614.8243
.8	181.5844	3340.84	193100.552	2623.8957
.9	181.8986	3352.41	194104.539	2632.9828
58	182.2128	3364	195112	2642.0856
.1	182.5269	3375.61	196122.941	2651.2046
.2	182.8411	3387.24	197137.368	2660.3382
.3	183.1552	3398.89	198155.287	2669.4882
.4	183.4694	3410.56	199176.704	2678.6538
.5	183.7836	3422.25	200201.625	2687.8351
.6	184.0977	3433.96	201230.056	2697.0321
.7	184.4119	3445.69	202262.003	2706.2449
.8	184.7260	3457.44	203297.472	2715.4733
.9	185.0402	3469.21	204336.469	2724.7175
59	185.3544	3481	205379	2733.9774
.1	185.6685	3492.81	206425.071	2743.2529
.2	185.9827	3504.64	207474.688	2752.5442
.3	186,2696	3516.49	208527.857	2761.8512
.4	186.6110	3528.36	209584.584	2771.1739
.5	186.9252	3540.25	210644.875	2780.5123
.6	187.2393	3552.16	211708.736	2789.8664
.7	187.5535	3564 09	212776.173	2799 2362
.8	187.8676	3576.04	213847.192	2808.6218
.9	188.1818	3588.01	214921.799	2818.0230

Diam.	Circum.	Square.	Cube.	Area.
60	188.4960	3600	216000	2827.4400
.1	188.8101	3612.01	217081.801	2836.8726
.2	189.1243	3624.04	218167.208	2846.3210
.3	189.4384	3636.09	219256.227	2855.7850
.4	189.7526	3648 16	220348.864	2865.2648
.5	190.0668	3660.25	221445.125	2874.7603
.6	190.3809	3672.36	222545.016	2884.2615
.7	190.6951	3684.49	223648.543	2893.7984
.8	191.0092	3696.64	224755.712	2903.3410
.9	191.3234	3708.81	225866.529	2912.8993
61	191.6376	3721	226981	2922.4734
.1	191.9517	3733.21	228099.131	2932.0631
.2	192.2659	3745.44	229220.928	2941.6685
.3	192.5800	3757.69	230346.397	2951.2897
.4	192.8942	3769.96	231475.544	2960 9265
.5	193.2084	3782.25	232608.375	2970.5791
.6	193.5225	3794.56	233744.896	2980.2474
.7	193.8367	3806.89	234885.113	2989.9314
.8	194.1508	3819 24	236029.032	2999.6300
.9	194.4650	3831.61	237176.659	3009.3464
62	194.7792	3844	238328	3019.0776
.1	195.0933	3856.41	239483.061	3028 8244
.2	195.4075	3868.84	240641.848	3038.5869
.3	195.7216	3881.29	241804.367	3048.3651
.4	196.0358	3893.76	242970.624	3058.1591
.5	196.3500	3906.25	244140.625	3067.9687
.6	196.6641	3918.76	245314.376	3077 7941
.7	196.9783	3931.29	246491.883	3087.6341
.8	197.2924	3943.84	247673.152	3097.4919
.9	197.6066	3956.41	248858.189	3107.3644
63	197.9208	3969	250047	3117.2526
.1	198.2349	3981.61	251239 591	3127.1564
.2	198.5491	3994.24	252435.968	3137.0758
.3	198.8632	4006.89	253636.137	3147.0114
.4	199.1774	4019.56	254840.104	3156.9664
.5	199.4916	4032.25	256047.875	3166.9291
.6	199.8057	4044.96	257259.456	3176.9115
.7	200.1199	4057.69	258474.853	3186.9097
.8	200.4340	4070.44	259694.072	3196 9235
.9	200.7482	4083.21	260917.119	3206.9531
64	201.0624	4096	262144	3216.9984
.1	201.3765	4108,81	263374.721	3227.0593
.2	201.6907	4121.64	264609.288	3237.1360
.3	202.0048	4134 49	265847.707	3247.2284
.4	202 3190	4147.36	267089.984	3257.3365
.5	202.6332	4160.25	268336.125	3267.4603
.6	202.9473	4173.16	269586.136	3277.5998
.7	203 2615	4186,09	270840 023	3287.7550
.8	203.5756	4199.04	272097.792	3297.9260
.9	203.8898	4212.01	273359·449	3308.1126

Diam.	Circum.	Square.	Cube.	Area.
65	204.2040	4225	274625	3318.3150
.1	204.5181	4238.01	275894 451	3328.5340
.2	204.8323	4251.04	277167.808	3338 7668
.3	205.1464	4264.09	278445.077	3349 0162
.4	205.4606	4277.16	279726.264	3359.2814
.5	205.7748	4290.25	281011.375	3369.5623
.6	206.0889	4303.36	282300.416	3379.8589
.7	206.4031	4316.49	283593.393	3390.1712
.8	206.7172	4329.64	284890.312	3400.4992
.9	207.0314	4342.81	286191.179	3410.8429
66	207.3456	4356	287496	3421.2024
.1	207.6597	4369.21	288804.781	3431.5775
.2	207.9739	4382.44	290117.528	3441.9633
.3	208.2880	4395.69	291434.247	3452.3749
.4	208.6022	4408.96	292754.944	3462.7971
.5	208.9164	4422.25	294079.625	3473.2351
.6	209.2305	4435.56	295408.296	3483.6888
.7	209.5447	4448.89	296740.963	3494.1640
.8	209.8588	4462.24	298077.632	3504.6432
.9	210.1730	4475.61	299418.309	3515.1430
67	210.4872	4489	300763	3525.6606
.1	210.8013	4502.41	302111.711	3536.1928
.2	211.1155	4515.84	303464.448	3546.7407
.3	211.4296	4529.29	304821.217	3557.3043
.4	211.7438	4542.76	306182.024	3567.8837
.5	212.0580	4556.25	307546.875	3578.4787
.6	212.3721	4569.76	308915.776	3589.0895
.7	212.6863	4583.29	310288.733	3599.7159
.8	213.0004	4596.84	311665.752	3610.3581
.9	213.3146	4610.41	313046.839	3621.0160
68	213.6288	4624	314432	3631.6896
.1	213.9429	4637.61	315821.241	3642.3788
.2	214.2571	4651.24	317214.568	3653.0838
.3	214.5712	4664.89	318611.987	3663.8040
.4	214.8854	4678.56	320013.504	3674.5410
.5	215.1996	4692.25	321419.125	3685.2931
.6	215.5137	4705.96	322828.856	3696.0060
.7	215.8279	4719.69	324242.703	3706.8445
.8	216.1420	4733.44	325660.672	3717.6437
.9	216.4562	4747.21	327082.769	3728.4587
69	216.7704	4761	328509	3739.2894
.1	217.0845	4774.81	329939.371	3750.1357
.2	217.3987	4788.64	331373.888	3760.9978
.3	217.7128	4802.49	332812.557	3771.8756
.4	218.0270	4816.36	334255.384	3782.7691
.5	218.3412	4830.25	335702.375	3793.6783
.6	218.6553	4844.16	337153.536	3804.6032
.7	218.9695	4858.09	338608.873	3815.5438
.8	219.2836	4872.04	340068.392	3826.5002
.9	219.5978	4886.01	341532.099	3837.4722

Diam.	Circum.	Square.	Cube.	Area.
70	219.9120	4900	343000	3848.4600
.1	220.2261	4914.01	344472.101	3859.4952
.2	220.5403	4928.04	345948.408	3870.4826
.3	220.8544	4942.09	347428.927	3881.5174
.4	221.1686	4956.16	348913.664	3892.5680
.5	221.4828	4970.25	350402.625	3903.6343
.6	221.7969	4984.36	351895.816	3914.7163
.7	222.1111	4998.49	353393.243	3925.8140
.8	222.4252	5012.64	354894.912	3936.9274
.9	222.7394	5026.81	356400.829	3948.0565
71	223.0536	5041	357911	3959.2014
.1	223.3677	5055.21	359425.431	3970.3619
.2	223.6819	5069.44	360944.128	3981.5381
.3	223.9960	5083.69	362467.097	3992.7301
.4	224.3102	5097.96	363994.344	4003.9373
.5	224.6244	5112.25	365525.875	4015.1611
.6	224.9385	5126.56	367061.696	4026.4002
.7	225.2527	5140.89	368601.813	4037.6550
.8	225.5668	5155.24	370146.232	4048.9254
.9	225.8810	5169.61	371694.959	4060.2116
72	226.1952	5184	373248	4071.5136
.1	226.5093	5198.41	374805.361	4082.8332
.2	226.8235	5212.84	376367.048	4094.1645
.3	227.1376	5227.29	377933.067	4105.5125
.4	227.4518	5241.76	379503.424	4116.8793
.5	227.7660	5256.25	381078.125	4128.2587
.6	228.0801	5270.76	382657.176	4139.6524
.7	228.3943	5285.29	384240.583	4151.0667
.8	228.7084	5299.84	385828.352	4162.4943
.9	229.0226	5314.41	387420.489	4173.9376
73	229.3368	5329	389017	4185.3966
.1	229.6509	5343.61	390617.891	4196.8712
.2	229.9651	5358.24	392223.168	4208.3614
.3	230.2792	5372.89	393832.837	4219.8678
.4	230.5934	5387.56	395446.904	4231.3896
.5	230.9076	5402.25	397065.375	4242.9271
.6	231.2217	5416.96	398688.256	4254.4803
.7	231.5359	5431.69	400315.553	4266.0493
.8	231.8500	5446.44	401947.272	4277.6339
.9	232.1642	5461.21	403583.419	4289.2343
74	232.4784	5476	405224	4300.8504
.1	232.7925	5490.81	406869.021	4312.4821
.2	233.1067	5505.64	408518.488	4324.1296
.3	233.4208	5520.49	410172.407	4335.7928
.4	233.7350	5535.36	411830.784	4347.4717
.5	234.0492	5550.25	413493.625	4359.1663
.6	234.3633	5565.16	415160.936	4370.8766
.7	234.6775	5580.09	416832.723	4382.6026
.8	234.9916	5595.04	418508.992	4394.3448
.9	235.3058	5610.01	420189.749	4406.1018

Diam.	Circum.	Square.	Cube.	Area.
75	235.6200	5625	421875	4417.8750
.1	235.9341	5640.01	423564.751	4429.6638
.2	236.2483	5655.04	425259.008	4441.4684
.3	236.5624	5670.09	426957.777	4453.2886
.4	236.8766	5685.16	428661.064	4465.1246
.5	237.1908	5700.25	430368.875	4476.9763
.6	237.5049	5715.36	432081.216	4488.8437
.7	237.8191	5730.49	433798.093	4500.7268
.8	238.1332	5745.64	435519.512	4512.6256
.9	238.4474	5760.81	437245.479	4524.5401
76	238.7616	5776	438976	4536.4704
.1	239.0757	5791.21	440711.081	4548.4163
.2	239.3899	5806.44	442450.728	4560.3787
.3	239.7040	5821.69	444194.947	4572.3553
.4	240.0182	5836.96	445943.744	4584.3583
.5	240.3324	5852.25	447697.125	4596.3571
.6	240.6465	5867.56	449455.096	4608.3816
.7	240.9607	5882.89	451217.663	4620.4218
.8	241.2748	5898.24	452984.832	4632.4776
.9	241.5987	5913.61	454756.609	5644.5492
77	241.9032	5929	456533	4656.6366
.1	242.2173	5944.41	458314.011	4668.7396
.2	242.5315	5959.84	460099.648	4680.8583
.3	242.8456	5975.29	461889.917	4692.9927
.4	243.1598	5990.76	463684.824	4705.1429
.5	243.4740	6006.25	465484.375	4717.3087
.6	243.7881	6021.76	467288.576	4729.4903
.7	244.1023	6037.29	469097.433	4741.6875
.8	244.4164	6052.84	470910.952	4753.9605
.9	244.7306	6068.41	472729.139	4766.1292
78	245.0448	6084	474552	4778.3736
.1	245.3589	6099.61	476379.541	4790.6336
.2	245.6731	6115.24	478211.768	4802.9094
.3	245.9872	6130.89	480048.687	4815.2010
.4	246.3014	6146.56	481890.304	4827.5082
.5	246.6156	6162.25	483736.625	4839.8311
.6	246.9297	6177.96	485587.656	4852.1697
.7	247.2439	6193.69	487443.403	4864.5241
.8	247.5480	6209.44	489303.872	4876.8973
.9	247.8722	6225.21	491169.069	4889.2799
79	248.1864	6241	493039	4901.6814
.1	248.5005	6256.81	494913.671	4914.0985
.2	248.8147	6272.64	496793.088	4926.5314
.3	249.1288	6288.49	498677.257	4938.9820
.4	249.4430	6304.36	500566.184	4951.4443
.5	249.7572	6320.25	502459.875	4963.9243
.6	250.0713	6336.16	504358.336	4976.4840
.7	250.3855	6352.09	506261.573	4988.9314
.8	250.6996	6368.04	508169.592	5001.4586
.9	251.0138	6384.01	510082.399	5014.0014

Diam.	Circum.	Square.	Cube.	Area.
80	251.3280	6400	512000	5026.5600
.1	251.6421	6416.01	513922.401	5039.1342
.2	251.9563	6432.04	515849.608	5051.7242
.3	252.2704	6448.09	517781.627	5064.3298
.4	252.5846	6464.16	519718.464	5076.9552
.5	252.8988	6480.25	521660.125	5089.5883
.6	253.2129	6496.36	523606.616	5102.2411
.7	253.5271	6512.49	525557.943	5114.9096
.8	253.8412	6528.64	527514.112	5127.5938
.9	254.1554	6544.81	529475.129	5140.2937
81	254.4696	6561	531441	5153.0094
.1	254.7837	6577.21	533411.731	5165.7407
.2	255.0979	6593.44	535387.328	5178.4877
.3	255.4120	6609.69	537367.797	5191.2505
.4	255.7262	6625.96	539353.144	5204.0285
.5	256.0404	6642.25	541343.375	5216.8231
.6	256.3545	6658.56	543338.496	5229.6330
.7	256.6687	6674.89	545338.513	5242.4586
.8	256.9828	6691.24	547343.432	5255.2998
.9	257.2970	6707.61	549353.259	5268.1568
82	257.6112	6724	551368	5281.0296
.1	257.9253	6740.41	553387.661	5293.9180
.2	258.2395	6756.84	555412.248	5306.8221
.3	258.5536	6773.29	557441.767	5319.7439
.4	258.8646	6789.76	559476.224	5332.6775
.5	259.1820	6806.25	561515.625	5345.6287
.6	259.4961	6822.76	563559.976	5358.5957
.7	259.8103	6839.29	565609.283	5371.5983
.8	260.1244	6855.84	567663.552	5384.5762
.9	260.4386	6872.41	569722.789	5397.5908
83	260.7528	6889	571787	5410.6206
.1	261.0669	6905.61	573856.191	5423.6660
.2	261.3811	6922.24	575930.368	5436.7272
.3	261.6952	6938.89	578009.537	5449.8042
.4	262.0094	6955.56	580093.704	5462.8968
.5	262.3236	6972.25	582182.875	5476.0051
.6	262.6376	6988.96	584277.056	5489.1291
.7	262.9519	7005.69	586376.253	5502.2689
.8	563.2640	7022.44	588480.472	5515.4243
.9	263.5802	7039.21	590589.719	5528.5958
84	263.8944	7056	592704	5541.7824
.1	264.2085	7072.81	594823.321	5554.9849
.2	264.5227	7089.64	596947.688	5568.2032
.3	264.8368	7106.49	599077.107	5581.4372
.4	265.1510	7123.36	601211.584	5594.6869
.5	265.4652	7140.25	603351.125	5607.9523
.6	265.7793	7157.16	605495.736	5621.2334
.7	266.0935	7174.09	607645.423	5634.5682
.8	266.4076	7191.04	609800.192	5647.8428
.9	266.7218	7208.01	611960.049	5661.1710

Diam.	Circum.	Square.	Cube.	Area.
85	267.0360	7225	614125	5674.5150
.1	267.3501	7242.01	616295.051	5687.8746
.2	267.6643	7259.04	618470.208	5701.2500
.3	267.9784	7276.09	620650.477	5714.6410
.4	268.2926	7293.16	622835.864	5728.0478
.5	268.6068	7310.25	625026.375	5741.4703
.6	268.9209	7327.36	627222.016	5754.9085
.7	269.2351	7344.49	629422.793	5768.3624
.8	269.5492	7361.64	631628.712	5781.8320
.9	269.8634	7378.81	633839.779	5795.3173
86	270.1776	7396	636056	5808.8184
.1	270.4917	7413.21	638277.381	5822.3351
.2	270.8059	7430.44	640503.928	5835.8675
.3	271.1200	7447.69	642735.647	5849.4157
.4	271.4342	7464.96	644972.544	5862.9795
.5	271.7484	7482.25	647214.625	5876.5591
.6	272 0625	7499.56	649461.896	5890.1541
.7	272.3767	7516.89	651714.363	5903.7654
.8	272.6908	7534.24	653972.032	5917.3920
.9	273.0050	7551.61	656234.909	5931.0344
87	273.3192	7569	658503	5944.6926
.1	273.6333	7586.41	660776.311	5958.3664
.2	273.9475	7603.84	663054.848	5972.0559
.3	274.2616	7621.29	665338.617	5985.7691
.4	274.5758	7638.76	667627.624	5999.4821
.5	274 8900	7656.25	669921.875	6013.2187
.6	275.2041	7673.76	672221.376	6026.9711
.7	275.5183	7691.29	674526.133	6040.7391
.8	275.8324	7708.84	676836.152	6054.5149
.9	276.1466	7726.41	679151.439	6068.3224
88	276.4608	7744	681472	6082.1376
.1	276.7749	7761.61	683797.841	6095.9684
.2	277.0891	7779.24	686128.968	6109.8150
.3	277.4032	7796.89	688465.387	6123.6774
.4	277.7174	7814.56	690807.104	6137.5554
.5	278 0316	7832.25	693154.122	6151.4491
.6	278.3457	7849.96	695506.456	6165.3585
.7	278 6599	7867.69	697864.103	6179.2837
.8	278.9750	7885.44	700227.072	6193.2245
.9	279.2882	7903.21	702595.369	6207.1811
89	279.6024	7921	704969	6221.1534
.1	279.9165	7938.81	707347.971	6235.1413
.2	280.2307	7956.64	709732.288	6249.1450
.3	280.5448	7974.49	712121.957	6263.1644
.4	280.8590	7992.36	714516.984	6277.1995
.5	281.1732	8010.25	716917.375	6291.2035
.6	281.4873	8028.16	719323.136	6305.3168
.7	281.8025	8046.09	721734.273	6319.3990
.8	282.1156	8064.04	724150.792	6333.4970
.9	282.4298	8082.01	726572.699	6347.6813

Diam.	Circum.	Square.	Cube.	Area.
90	282.7440	8100	729000	6361.7400
.1	283.0581	8118.01	731432.701	6375.8850
.2	283.3723	8136.04	733870.808	6390.0458
.3	283.6864	8154.09	736314.327	6404.2222
.4	284.0006	8172.16	738763.264	6418.4144
.5	284.3148	8190.25	741217.625	6432.6223
.6	284.6289	8208 36	743677.416	6446.8474
.7	284.9431	8226.49	746142.643	6461.0852
.8	285.2572	8244 64	748613.312	6475.3402
.9	285.5714	8262.81	751089.429	6489.6109
91	285.8856	8281	753571	6503.8974
.1	286.1997	8299.21	756058.031	6518.1995
.2	286.5139	8317.44	758550.528	6532.5173
.3	286.8290	8335.69	761048.497	6546.8909
.4	287.1422	8353.96	763551.944	6561.2081
.5	287.4564	8372.25	766060.875	6575.5651
.6	287.7705	8390.56	768575.296	6589.9458
.7	288.0847	8408.89	771095.213	6604.3222
.8	288.3988	8427.24	773620.632	6618.7542
.9	288.7130	8445.61	776151.559	6633.1820
92	289.0272	8464	778688	6647.6256
.1	289.3413	8482.41	781229.961	6662.0848
.2	289.6555	8500.84	783777.448	6676.5597
.3	289.9696	8519.29	786330 467	6691.0161
.4	290.2838	8537.76	788889.024	6705.5567
.5	290.5980	8556.25	791453.125	6720.0787
.6	290.9121	8574 76	794022.776	6734.6165
.7	291.2263	8593.29	796597.983	6749.1699
.8	291.5404	8611.84	799178.752	6763.7391
.9	291.8546	8630.41	801765.089	6778.3240
93	292.1688	8649	804357	6792.9246
.1	292.4829	8667.61	806954.491	6807.5408
.2	292.7971	8686.24	809557.568	6822.1730
.3	293.1112	8704.89	812166.237	6836.8206
.4	293.4254	8723.56	814780.504	6851.4840
.5	293.7396	8742.25	817400 375	6866.1631
.6	294.0537	8760.96	820025.856	6880.8579
.7	294.3679	8779.69	822656.953	6895.5685
.8	294.6820	8798.44	825293.672	6910.2947
.9	294.9962	8817.21	827936.019	6925.0367
94	295.3104	8836	830584	6939.7944
.1	295.6245	8854.81	833237.621	6954.5677
.2	295.9387	8873.64	835896.888	6969.3568
.3	296.2436	8892.49	838561.807	6984.1614
.4	296.5670	8911.36	841232.384	6998.9821
.5	296.8812	8930.25	843908.625	7013.8183
.6	297.1953	8949.16	846590.536	7028.6702
.7	297.5095	8968.09	849278.123	7043.5025
.8	297.8236	8987.04	851971.392	7058.4180
.9	298.1378	9006.01	854670.349	7073.3202

Diam.	Circum.	Square.	Cube.	Area
95	298.4520	9025	857375	7088.2350
.1	298 7661	9044.01	860085.351	7103.1654
.2	299.0723	9063.04	862801.408	7118.1116
.3	299.3944	9082.09	865523.177	7133.0734
.4	299.7086	9101.16	868250.664	7148.0510
.5	300.0228	9120.25	870983.875	7163.0443
.6	300.3369	9139.36	873722.816	7178.0533
.7	300.6511	9158.49	876467.493	7193.0780
.8	300 9652	9177.64	879217.912	7208.1184
.9	301.2794	9196.81	881974.079	7223.1745
96	301.5936	9216	884736	7238.2464
.1	301.9077	9235.21	887503.681	7253.3339
.2	302.2219	9254.44	890277.128	7268.4371
.3	302.5360	9273.69	893056.347	7283.5561
.4	302.8502	9292.96	895841.344	7298.6907
.5	303.1644	9312.25	898632.125	7313.8411
.6	303.4785	9331.56	901428.696	7329.0072
.7	303.7927	9350.89	904231.063	7344.1890
.8	304.1068	9370.24	907039.232	7359.3864
.9	304.4210	9389.61	909853.209	7374.5996
97	304.7352	9409	912673	7389 8286
.1	305 0493	9428.41	915498.611	7405 0732
.2	305.3635	9447.84	918330.048	7420.3335
.3	305.6776	9467.29	921167.317	7435.6095
.4	305 9918	9486.76	924010.424	7450.9013
.5	306.3060	9506.25	926859.375	7466.2087
.6	306 6201	9525.76	929714.176	7481.5319
.7	306.9363	9545.29	932574.833	7496.8707
.8	307 2484	9564.84	935441.352	7512.2253
.9	307.5626	9584.41	938313.739	7527.5956
98	307.8768	9604	941192	7542 9816
.1	308.1909	9623.61	944076.141	7558.3832
.2	308 5051	9643.24	946966.168	7573.8006
.3	308.8192	9662.89	949862.087	7589.2338
.4	309 1334	9682.56	952763.904	7604.6826
.5	309.4476	9702.25	955671.625	7620.1471
.6	309.7617	9721.96	958585.256	7635.6273
.7	310.0759	9741.69	961504.803	7651.1933
.8	310.3960	9761.44	964430.272	7666.6349
.9	310.7042	9781 21	967361.669	7682.1623
99	311.0184	9801	970299	7697.7054
.1	311.3325	9820.81	973242.271	7713.2641
.2	311.6467	9840.64	976191.488	7728.8386
.3	311.9608	9860.49	979146.657	7744.4288
.4	312.2750	9880.36	982107.784	7760.0347
.5	312.5892	9900.25	985074.875	7775.6563
.6	312.9033	9920.16	988047.936	7791.2936
.7	313.2175	9940.09	991026.973	7806.9466
.8	313.5116	9960.04	994011.992	7822.6154
.9	313.8458	9980.01	997002.999	7838.2998
100	314.1600	10000	1000000	7854.0000

TABLE

Containing the circumferences and areas of circles, from one-eighth to 100 inches, advancing by an eighth.

Diam.	Circum.	Area.	Diam.	Circum.	Area.
			5 in.	15.7080	19.6350
⅛	.3927	.0122	⅛	16.1007	20.6290
¼	.7854	.0490	¼	16.4934	21.6475
⅜	1.1781	.1104	⅜	16.8861	22.6907
½	1.5708	.1963	½	17.2788	23.7583
⅝	1.9635	.3068	⅝	17.6715	24.8505
¾	2.3562	.4417	¾	18.0642	25.9672
⅞	2.7489	.6013	⅞	18.4569	27.1085
1 in.	3.1416	.7854	6 in.	18.8496	28.2744
⅛	3.5343	.9940	⅛	19.2423	29.4647
¼	3.9270	1.2271	¼	19.6350	30.6796
⅜	4.3197	1.4848	⅜	20.0277	31.9192
½	4.7124	1.7671	½	20.4204	33.1831
⅝	5.1051	2.0739	⅝	20.8131	34.4717
¾	5.4978	2.4052	¾	21.2058	35.7847
⅞	5.8905	2.7611	⅞	21.5985	37.1224
2 in.	6 2832	3.1416	7 in.	21.9912	38.4846
⅛	6.6759	3.5465	⅛	22.3839	39.8713
¼	7.0686	3.9760	¼	22.7766	41.2825
⅜	7.4613	4.4302	⅜	23.1693	42.7184
½	7.8540	4.9087	½	23 5620	44.1787
⅝	8.2467	5 4119	⅝	23.9547	45.6636
¾	8.6394	5.9395	¾	24.3474	47.1730
⅞	9.0321	6 4918	⅞	24.7401	48.7070
3 in.	9.4248	7.0686	8 in.	25.1328	50 2656
⅛	9.8175	7.6699	⅛	25.5255	51.8486
¼	10.2102	8 2957	¼	25.9182	53.4562
⅜	10 6029	8.9462	⅜	26.3109	55.0885
½	10.9956	9.6211	½	26.7036	56.7451
⅝	11.3883	10 3206	⅝	27.0963	58.4264
¾	11.7810	11.0446	¾	27.4890	60.1321
⅞	12.1737	11.7932	⅞	27.8817	61.8625
4 in.	12.5664	12 5664	9 in.	28 2744	63.6174
⅛	12.9591	13.3640	⅛	28.6671	65.3968
¼	13 3518	14.1862	¼	29.0598	67.2007
⅜	13.7445	15.0331	⅜	29.4525	69.0293
½	14 1372	15 9043	½	29.8452	70.8823
⅝	14.5299	16.8001	⅝	30.2379	72.7599
¾	14.9226	17.7205	¾	30.6306	74.6620
⅞	15.3153	18.6655	⅞	31.0233	76.5887

Diam.	Circum.	Area.	Diam.	Circum.	Area.
10 in.	31.4160	78.5400	16 in.	50.2656	201.0624
⅛	31.8087	80.5154	⅛	50.6583	204.2162
¼	32.2014	82.5160	¼	51.0510	207.3946
⅜	32.5941	84.5409	⅜	51.4437	210.5976
½	32.9868	86.5903	½	51.8364	213 8251
⅝	33.3795	88.6643	⅝	52.2291	217.0772
¾	33.7722	90.7627	¾	52.6218	220.3537
⅞	34.1649	92.8858	⅞	53.0145	223.6549
11 in.	34.5576	95.0334	17 in.	53.4072	226.9806
⅛	34.9503	97.2055	⅛	53.7999	230.3308
¼	35.3430	99.4021	¼	54.1926	233.7055
⅜	35.7357	101.6234	⅜	54.5853	237.1049
½	36.1284	103.8691	½	54.9780	240.5287
⅝	36.5211	106.1394	⅝	55.3707	243 9771
¾	36.9138	108.4342	¾	55.7634	247 4500
⅞	37.3065	110.7536	⅞	56.1561	250 9475
12 in.	37.6992	113.0976	18 in.	56.5488	254.4696
⅛	38.0919	115.4660	⅛	56.9415	258.0161
¼	38.4846	117.8590	¼	57.3342	261 5872
⅜	38.8773	120.2766	⅜	57.7269	265 1829
½	39.2700	122.7187	½	58.1196	268 8031
⅝	39.6627	125.1854	⅝	58.5123	272 4479
¾	40.0554	127.6765	¾	58.9050	276.1171
⅞	40.4481	130.1923	⅞	59.2977	279.8110
13 in.	40.8408	132.7326	19 in.	59.6904	283.5294
⅛	41.2335	135.2974	⅛	60.0831	287.2723
¼	41.6262	137.8867	¼	60.4758	291.0397
⅜	42.0189	140.5007	⅜	60.8685	294.8312
½	42.4116	143.1391	½	61.2612	298.6483
⅝	42.8043	145.8021	⅝	61.6539	302.4894
¾	43.1970	148.4896	¾	62.0466	306.3550
⅞	43.5897	151.2017	⅞	62.4393	310.2452
14 in.	43.9824	153.9384	20 in.	62.8320	314.1600
⅛	44.3751	156.6995	⅛	63.2247	318 0992
¼	44.7678	159.4852	¼	63.6174	322.0630
⅜	45.1605	162.2956	⅜	64.0101	326.0514
½	45.5532	165.1303	½	64.4028	330.0643
⅝	45 9459	167.9896	⅝	64.7955	334.1018
¾	46.3386	170.8735	¾	65.1882	338.1637
⅞	46.7313	173.7820	⅞	65.5809	342.2503
15 in.	47.1240	176.7150	21 in.	65.9736	346.3614
⅛	47.5167	179.6725	⅛	66.3663	350.4970
¼	47.9094	182.6545	¼	66.7590	354.6571
⅜	48.3021	185.6612	⅜	67.1517	358.8419
½	48.6948	188.6923	½	67.5444	363.0511
⅝	49.0875	191.7480	⅝	67.9371	367.2849
¾	49.4802	194.8282	¾	68.3298	371.5432
⅞	49.8729	197.9330	⅞	68.7225	375.8261

Diam.	Circum.	Area.	Diam.	Circum.	Area.
22 in.	69.1152	380.1336	28 in.	87.9648	615.7536
⅛	69.5079	384.4655	⅛	88.3575	621.2636
¼	69.9006	388.8220	¼	88.7502	626.7982
⅜	70.2933	393.2031	⅜	89.1429	632.3574
½	70.6860	397.6087	½	89.5356	637.9411
⅝	71.0787	402.0388	⅝	89.9283	643.5494
¾	71.4714	406.4935	¾	90.3210	649.1821
⅞	71.8641	410.9728	⅞	90.7137	654.8395
23 in.	72.2568	415.4766	29 in.	91.1064	660.5214
⅛	72.6495	420.0049	⅛	91.4991	666.2278
¼	73.0422	424.5577	¼	91.8918	671.9587
⅜	73.4349	429.1352	⅜	92.2845	677.7143
½	73.8276	433.7371	½	92.6772	683.4943
⅝	74.2203	438.3636	⅝	93.0699	689.2989
¾	74.6130	443.0146	¾	93.4626	695.1280
⅞	75.0057	447.6902	⅞	93.8553	700.9817
24 in.	75.3984	452.3904	30 in.	94.2480	706.8600
⅛	75.7911	457.1150	⅛	94.6407	712.7627
¼	76.1838	461.8642	¼	95.0334	718.6900
⅜	76.5765	466.6380	⅜	95.4261	724.6419
½	76.9692	471.4363	½	95.8188	730.6183
⅝	77.3619	476.2592	⅝	96.2115	736.6193
¾	77.7546	481.1065	¾	96.6042	742.6447
⅞	78.1473	485.9785	⅞	96.9969	748.6948
25 in.	78.5400	490.8750	31 in.	97.3896	754.7694
⅛	78.9327	495.7960	⅛	97.7823	760.8685
¼	79.3254	500.7415	¼	98.1750	766.9921
⅜	79.7181	505.7117	⅜	98.5677	773.1404
½	80.1108	510.7063	½	98.9604	779.3131
⅝	80.5035	515.7255	⅝	99.3531	785.5104
¾	80.8962	520.7692	¾	99.7458	791.7322
⅞	81.2889	525.8375	⅞	100.1385	797.9786
26 in.	81.6816	530.9304	32 in.	100.5312	804.2496
⅛	82.0743	536.0477	⅛	100.9239	810.5450
¼	82.4670	541.1896	¼	101.3166	816.8650
⅜	82.8597	546.3561	⅜	101.7093	823.2096
½	83.2524	551.5471	½	102.1020	829.5787
⅝	83.6451	556.7627	⅝	102.4947	835.9724
¾	84.0378	562.0027	¾	102.8874	842.3905
⅞	84.4305	567.2674	⅞	103.2801	848.8333
27 in.	84.8232	572.5566	33 in.	103.6728	855.3006
⅛	85.2159	577.8703	⅛	104.0655	861.7924
¼	85.6086	583.2085	¼	104.4582	868.3087
⅜	86.0013	588.5714	⅜	104.8509	874.8497
½	86.3940	593.9587	½	105.2436	881.4151
⅝	86.7867	599.3706	⅝	105.6363	888.0051
¾	87.1794	604.8070	¾	106.0290	894.6196
⅞	87.5721	610.2680	⅞	106.4217	901.2587

Diam.	Circum.	Area.	Diam.	Circum.	Area.
34 in.	106.8144	907.9224	40 in.	125.6640	1256.6400
⅛	107.2071	914.6105	⅛	126.0567	1264.5062
¼	107.5998	921.3232	¼	126 4494	1272.3970
⅜	107.9925	928.0605	⅜	126.8421	1280.3124
½	108.3852	934.8223	½	127.2348	1288.2523
⅝	108.7779	941.6087	⅝	127.6275	1296.2168
¾	109.1706	948.4195	¾	128.0202	1304.2057
⅞	109.5633	955.2550	⅞	128.4129	1312.2193
35 in.	109.9560	962.1150	41 in.	128.8056	1320.2574
⅛	110.3487	968.9995	⅛	129.1983	1328.3200
¼	110.7414	975.9085	¼	129.5910	1336.4071
⅜	111.1341	982.8422	⅜	129.9837	1344.5189
½	111 5268	989.8003	½	130 3764	1352.6551
⅝	111.9195	996.7830	⅝	130.7691	1360.8159
¾	112.3122	1003.7902	¾	131.1618	1369.0012
⅞	112.7049	1010.8220	⅞	131.5545	1377.2111
36 in.	113 0977	1017.8784	42 in.	131.9472	1385.4456
⅛	113.4903	1024.9592	⅛	132.3399	1393.7045
¼	113 8830	1032 0646	¼	132.7326	1401.9880
⅜	114.2757	1039.1946	⅜	133 1253	1410.2961
½	114.6684	1046.3491	½	133.5180	1418.6287
⅝	115.0611	1053.5281	⅝	133.9107	1426.9859
¾	115.4538	1060.7317	¾	134 3034	1435.3675
⅞	115.8465	1067.9599	⅞	134.6961	1443.7738
37 in.	116.2392	1075.2126	43 in.	135.0888	1452.2046
⅛	116.6319	1082.4898	⅛	135.4815	1460.6599
¼	117.0246	1089 7915	¼	135.8742	1469.1397
⅜	117.4173	1097.1179	⅜	136.2669	1477.6342
½	117.8100	1104.4687	½	136.6596	1486.1731
⅝	118.2027	1111.8441	⅝	137.0523	1494.7266
¾	118.5954	1119.2440	¾	137.4450	1503.3046
⅞	118.9881	1126.6685	⅞	137.8377	1511.9072
38 in.	119.3808	1134.1176	4 in.	138.2304	1520 5344
⅛	119.7735	1141.5911	⅛	138.6231	1529.1860
¼	120.1662	1149.0892	¼	139.0158	1537.8622
⅜	120.5589	1156.6119	⅜	139 4085	1546.5530
½	120.9516	1164.1591	½	139.8012	1555.2883
⅝	121.3443	1171.7309	⅝	140.1939	1564.0382
¾	121.7370	1179.3271	¾	140.5866	1572.8125
⅞	122.1297	1186.9480	⅞	140.9793	1581.6115
39 in.	122.5224	1194.5934	45 in.	141.3720	1590.4350
⅛	122 9151	1202.2633	⅛	141.7647	1599.2830
¼	123.3078	1209.9577	¼	142.1574	1608.1555
⅜	123.7005	1217.6768	⅜	142.5505	1617.0427
½	124.0932	1225.4203	½	142.9428	1625.9743
⅝	124.4859	1233.1884	⅝	143.3355	1634.9205
¾	124.8786	1240.9810	¾	143.7282	1643.8912
⅞	125.2713	1248.7982	⅞	144.1209	1652.8865

Diam.	Circum.	Area.	Diam.	Circum.	Area.
46 in.	144.5136	1661.9064	52 in.	163.3632	2123.7216
⅛	144 9063	1670.9507	⅛	163.7559	2133.9440
¼	145.2990	1680.0196	¼	164.1486	2144.1910
⅜	145.6917	1689.1031	⅜	164.5413	2154.4626
½	146.0844	1698 2311	½	164.9340	2164.7587
⅝	146.4771	1707.3737	⅝	165.3267	2175.0794
¾	146.8698	1716 5407	¾	165.7194	2185.4245
⅞	147.2625	1725.7324	⅞	166.1121	2195.7943
47 in.	147.6552	1734.9486	53 in.	166.5048	2206.1886
⅛	148.0479	1744.1893	⅛	166.8975	2216.6074
¼	148.4406	1753.4545	¼	167.2902	2227 0507
⅜	148.8333	1762.7344	⅜	167.6829	2237.5187
½	149.2260	1772.0587	½	168.0756	2248.0111
⅝	149 6187	1781.3976	⅝	168.4683	2258.5281
¾	150.0114	1790.7610	¾	168 8610	2269 0696
⅞	150.4041	1800.1490	⅞	169.2537	2279.6357
48 in.	150.7968	1809.5616	54 in.	169.6464	2290.2264
⅛	151.1895	1818.9986	⅛	170.0391	2300.8415
¼	151.5822	1828.4602	¼	170.4318	2311.4812
⅜	151.9749	1837.9364	⅜	170.8245	2322.1455
½	152.3676	1847.4571	½	171.2172	2332.8343
⅝	152.7603	1856.9924	⅝	171.6099	2343.5477
¾	153.1530	1866.5521	¾	172.0026	2354.2855
⅞	153.5457	1876.1365	⅞	172.3953	2365.0480
49 in.	153.9384	1885.7454	55 in.	172.7880	2375.8350
⅛	154.3311	1895 3788	⅛	173.1807	2386.6465
¼	154.7238	1905.0367	¼	173.5734	2397.4825
⅜	155.1165	1914.7093	⅜	173.9661	2408.3432
½	155.5092	1924.4263	½	174.3588	2419.2283
⅝	155.9019	1934 1579	⅝	174.7515	2430.1380
¾	156 2946	1943.9140	¾	175.1442	2441.0722
⅞	156.6873	1953.6947	⅞	175.5369	2452.0310
50 in.	157.0800	1963.5000	56 in.	175.9296	2463.0144
⅛	157.4727	1973.3297	⅛	176.3223	2474 0222
¼	157.8654	1983.1840	¼	176.7150	2485.0546
⅜	158.2581	1993.0529	⅜	177.1077	2496.1116
½	158.6508	2002.9663	½	177.5004	2507.1931
⅝	159 0435	2012.8943	⅝	177.8931	2518.2992
¾	159.4362	2022.8467	¾	178.2858	2529.4297
⅞	159.8289	2032.8238	⅞	178.6785	2540.5849
51 in.	160.2216	2042.8254	57 in.	179.0712	2551.7646
⅛	160 6143	2052.8515	⅛	179.4639	2562.9688
¼	161.0070	2062.9021	¼	179.8566	2574.1975
⅜	161 3997	2072.9674	⅜	180.2493	2585.4509
½	161.7924	2083.0771	½	180.6420	2596.7287
⅝	162.1851	2093.2014	⅝	181.0347	2608.0311
¾	162.5778	2103.3502	¾	181.4274	2619 3580
⅞	102.9705	2113.5236	⅞	181.8201	2630.7095

Dim.	Circum.	Area.	Diam.	Circum.	Area.
58 *in.*	182.2128	2642.0856	64 *in.*	201.0624	3216.9984
⅛	182.6055	2653.4861	⅛	201.4551	3229.5770
¼	182.9982	2664.9112	¼	201.8478	3242.1782
⅜	183 3909	2676.3609	⅜	202.2405	3254.8080
½	183.7836	2687.8351	½	202.6332	3267.4603
⅝	184.1763	2699.3338	⅝	203.0259	3280.1372
¾	184.5690	2710.8571	¾	203.4186	3292.8385
⅞	184.9617	2722.4050	⅞	203.8113	3305.5645
59 *in.*	185.3544	2733.9774	65 *in.*	204.2040	3318.3150
⅛	185.7471	2745.5743	⅛	204.5967	3331.0900
¼	186.1398	2757.1957	¼	204.9894	3343.8875
⅜	186.5325	2768.8418	⅜	205.3821	3356.7137
½	186.9252	2780.5123	½	205.7748	3369.5623
⅝	187.3179	2792.2074	⅝	206.1675	3382.4355
¾	187.7106	2803 9270	¾	206.5602	3395 3332
⅞	188.1033	2815.6712	⅞	206.9529	3408.2555
60 *in.*	188.4960	2827.4400	66 *in.*	207.3456	3421.2024
⅛	188.8887	2839.2332	⅛	207.7383	3434.1737
¼	189.2814	2851.0510	¼	208.1310	3447.1676
⅜	189.6741	2862.8934	⅜	208.5237	3460.1901
½	190.0668	2874.7603	½	208.9164	3473.2351
⅝	190.4595	2886.6517	⅝	209.3091	3486.3047
¾	190 8522	2898.5677	¾	209.7018	3499 3987
⅞	191.2449	2910.5083	⅞	210.0945	3512.5174
61 *in.*	191.6376	2922.4734	67 *in.*	210.4872	3525.6606
⅛	192.0303	2934.4630	⅛	210.8799	3538.8283
¼	192.4230	2946.4771	¼	211.2726	3552.0185
⅜	192.8157	2958.5159	⅜	211.6653	3565.2374
½	193.2084	2970.5791	½	212.0580	3578.4787
⅝	193.6011	2982.6669	⅝	212.4507	3591.7446
¾	193.9938	2994.7792	¾	212.8434	3605.0350
⅞	194.3865	3006.9161	⅞	213.2361	3618.3500
62 *in.*	194.7792	3019.0776	68 *in.*	213.6288	3631.6896
⅛	195.1719	3031.2635	⅛	214.0215	3645.0536
¼	195.5646	3043.4740	¼	214.4142	3658.4402
⅜	195.9573	3055.7091	⅜	214.8069	3671.8554
½	196.3500	3067.9687	½	215.1996	3685.2931
⅝	196.7427	3080.2529	⅝	215.5923	3698.7554
¾	197.1354	3092.5615	¾	215.9850	3712.2421
⅞	197.5281	3104.8948	⅞	216.3777	3725.7535
63 *in.*	197.9208	3117.2526	69 *in.*	216.7704	3739.2894
⅛	198.3135	3129.6349	⅛	217.1631	3752.8498
¼	198.7062	3142.0417	¼	217.5558	3766.4327
⅜	199.0989	3154.4732	⅜	217.9485	3780.0443
½	199.4916	3166.9291	½	218.3412	3793.6783
⅝	199.8843	3179.4096	⅝	218.7339	3807.3369
¾	200.2770	3191.9146	¾	219.1266	3821.0200
⅞	200.6697	3204.4442	⅞	219.5193	3834.7277

Diam.	Circum.	Area.	Diam.	Circum.	Area.
70 in.	219.9120	3848.4600	76 in.	238.7616	4536.4704
⅛	220.3047	3862.2167	⅛	239.1543	4551.4023
¼	220.6974	3875 9960	¼	239.5470	4566.3626
⅜	221.0901	3889.8039	⅜	239.9397	4581.3486
½	221.4828	3903.6343	½	240.3324	4596.3571
⅝	221.8755	3917.4893	⅝	240.7251	4611.3902
¾	222.2682	3931.3687	¾	241.1178	4626.4477
⅞	222.6609	3945.2728	⅞	241.5105	4641.5299
71 in.	223.0536	3959.2014	77 in.	241.9032	4656.6366
⅛	223.4463	3973.1545	⅛	242.2959	4671.7678
¼	223.8390	3987.1301	¼	242.6866	4686.9215
⅜	224.2317	4001.1344	⅜	243.0813	4702.1039
½	224 6244	4015.1611	½	243.4740	4717.3087
⅝	225.0171	4029.2124	⅝	243.8667	4732.5381
¾	225.4098	4043 2882	¾	244.2594	4747.7920
⅞	225.8025	4057.3886	⅞	244.6521	4763.0705
72 in.	226.1952	4071.5136	78 in.	245.0448	4778.3736
⅛	226.5879	4085.6631	⅛	245.4375	4793.7012
¼	226.9806	4099.8350	¼	245.8302	4809.0512
⅜	227.3733	4114.0356	⅜	246.2229	4824.4299
½	227.7660	4128.2587	½	246.6156	4839.8311
⅝	228.1587	4142.5064	⅝	247.0083	4855.2568
¾	228.5514	4156.7785	¾	247.4010	4870.7071
⅞	228.9441	4171.0753	⅞	247.7937	4886.1820
73 in.	229.3368	4185.3966	79 in.	248.1864	4901.6814
⅛	229.7295	4199.7424	⅛	248.5791	4917.2053
¼	230.1222	4214.1107	¼	248.9718	4932.7517
⅜	230.5149	4228 5077	⅜	249.3645	4948.3268
½	230.9076	4242 9271	½	249.7572	4963.9243
⅝	231.3003	4257.3711	⅝	250.1499	4979.5456
¾	331.6930	4271.8396	¾	250.5426	4995.1930
⅞	232.0857	4286.3327	⅞	250.9353	5010.8642
74 in.	232.4784	4300.8504	80 in.	251.3280	5026.5600
⅛	232.8711	4315.3926	⅛	251.7207	5042.2803
¼	233.2638	4329.9572	¼	252.1134	5058.0230
⅜	233.6565	4344.5505	⅜	252.5061	5073.7944
½	234.0492	4359.1663	½	252.8988	5089.5883
⅝	234.4419	4373.8067	⅝	253.2915	5105.4060
¾	234.8346	4388.4715	¾	253.6842	5121.2497
⅞	235.2273	4403.1610	⅞	254.0769	5137.1173
75 in.	235.6200	4417.8750	81 in.	254.4696	5153.0094
⅛	236.0127	4432.6135	⅛	254.8623	5168.9260
¼	236.4054	4447.3745	¼	255.2550	5184.8651
⅜	236.7981	4462.1642	⅜	255.6477	5200.8329
½	237.1908	4476.9763	½	256.0404	5216.8231
⅝	237.5835	4491.8130	⅝	256.4331	5232.8371
¾	237.9762	4506.6742	¾	256.8258	5248.8772
⅞	238.3689	4521.5600	⅞	257.2185	5264.9411

Diam.	Circum.	Area.	Diam.	Circum.	Area.
82 *in.*	257.6112	5281.0296	88 *in.*	276.4608	6082.1376
⅛	258.0039	5297.1426	⅛	276.8535	6099.4287
¼	258.3866	5313.2780	¼	277.2462	6116.7422
⅜	258.7993	5329.4421	⅜	277.6389	6134.0844
½	259.1820	5345.6287	½	278.0316	6151.4491
⅝	259.5747	5361.8391	⅝	278.4243	6168.8376
¾	259.9674	5378.0755	¾	278.8170	6186.2521
⅞	260.3601	5294.3358	⅞	279.2097	6203.6905
83 *in.*	260.7528	5410.6206	89 *in.*	279.6024	6221.1534
⅛	261.1455	5426.9299	⅛	279.9951	6238.6408
¼	261.5382	5443 2617	¼	280.3878	6256.1507
⅜	261.9309	5459.6222	⅜	280 7805	6273.6893
½	262.3236	5476.0051	½	281.1732	6291.2503
⅝	262 7163	5492.4118	⅝	281.5659	6308.8351
¾	263.1090	5508.8446	¾	281.9586	6326.4460
⅞	263.5017	5525.3012	⅞	282.3513	6344.0807
84 *in.*	263.8944	5541.7824	90 *in.*	282.7440	6361.7400
⅛	264 2871	5558.2881	⅛	283.1367	6379.4238
¼	264.6798	5574.8162	¼	283.5294	6397.1300
⅜	265.0725	5591 3730	⅜	283.9221	6414.8649
½	265.4652	5607.9523	½	284.3148	6432.6223
⅝	265.8579	5624.5554	⅝	284.7075	6450.4039
¾	266.2506	5641.1845	¾	285.1002	6468.2107
⅞	266.6433	5657.8357	⅞	285.4929	6486.0418
85 *in.*	267.0360	5674.5150	91 *in.*	285.8856	6503.8974
⅛	267.4287	5691 2170	⅛	286.2783	6521.7775
¼	267.8214	5707.9415	¼	286 6710	6539.6801
⅜	268.2141	5724.6947	⅜	287.0637	6557.6114
½	268.6068	5741.4703	½	287.4564	6575.5651
⅝	268.9995	5758.2697	⅝	287.8491	6593.5431
¾	269.3922	5775.0952	¾	288.2418	6611.5462
⅞	269.7849	5791 9445	⅞	288.6345	6629.5736
86 *in.*	270.1776	5808.8184	92 *in.*	289 0272	6647 6258
⅛	270.5703	5825.7168	⅛	289 4199	6665.7021
¼	270.9630	5842.6376	¼	289.8126	6683.8010
⅜	271.3557	5859.5871	⅜	290.2053	6701 9286
½	271.7484	5876.5591	½	290.5980	6720.0787
⅝	272.1411	5893.5549	⅝	290.9907	6738.2530
¾	272.5338	5910.5767	¾	291.3834	6756.4525
⅞	272.9265	5927.9224	⅞	291.7761	6774 6763
87 *in.*	273.3192	5944.6926	93 *in.*	292.1688	6792.9248
⅛	273.7119	5961.7873	⅛	292.5615	6811.1974
¼	274.1046	5978.9045	¼	292.9542	6829.4927
⅜	274 4973	5996.0504	⅜	293.3469	6847.8167
½	274.8900	6013.2187	½	293 7396	6866.1631
⅝	275.2827	6030 4108	⅝	294 1323	6884.5338
¾	275.6754	6047.6290	¾	294.5250	6902.9296
⅞	276.0681	6064.8710	⅞	294.9177	6921.3497

Diam.	Circum.	Area.	Diam.	Circum.	Area.
94 *in.*	295.3104	6939.7946	97 *in.*	304.7352	7389.8288
⅛	295.7031	6958.2636	⅛	305.1279	7408.8868
¼	296.0958	6976.7552	¼	305.5206	7427.9675
⅜	296.4885	6995.2755	⅜	305.9133	7447.0769
½	296.8812	7013.8183	½	306.3060	7466.2087
⅝	297.2739	7032.3853	⅝	306.6987	7485.3648
¾	297.6666	7050.9775	¾	307.0914	7504.5460
⅞	298.0593	7069.5940	⅞	307.4841	7523.7515
95 *in.*	298.4520	7088.2352	98 *in.*	307.8768	7542.9818
⅛	298.8447	7106.9005	⅛	308.2695	7562.2362
¼	299.2374	7125.5885	¼	308.6622	7581.5132
⅜	299.6301	7144.3052	⅜	309.0549	7600.8189
½	300.0228	7163.0443	½	309.4476	7620.1471
⅝	300.4155	7181.8077	⅝	309.8403	7639.4995
¾	300.8082	7200.5962	¾	310.2330	7658.8771
⅞	301.2009	7219.4090	⅞	310.6257	7678.2790
96 *in.*	301.5936	7238.2466	99 *in.*	311.0184	7697.7056
⅛	301.9863	7257.1083	⅛	311.4111	7717.1563
¼	302.3790	7275.9926	¼	311.8038	7736.6297
⅜	302.7717	7294.9056	⅜	312.1965	7756.1318
½	303.1644	7313.8411	½	312.5892	7775.6563
⅝	303.5571	7332.8008	⅝	312.9819	7795.2051
¾	303.9498	7351.7857	¾	313.3746	7814.7790
⅞	304.3425	7370.7949	⅞	313.7673	7834.3772
			100 *in.*	314.1600	7854.0000

TABLE

Containing the circumferences and areas of circles from 1 *to* 50 *feet, and advancing by an inch.*

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
1 *ft.*	3.1416	.7854	4 *ft.*	12.5664	12.5664
1	3.4034	.9217	1	12.8282	13.0952
2	3.6652	1.0690	2	13.0900	13.6353
3	3.9270	1.2271	3	13.3518	14.1862
4	4.1888	1.3962	4	13.6136	14.7479
5	4.4506	1.5761	5	13.8754	15.3206
6	4.7124	1.7671	6	14.1372	15.9043
7	4.9742	1.9689	7	14.3990	16.4986
8	5.2360	2.1816	8	14.6608	17.1041
9	5.4978	2.4052	9	14 9226	17.7205
10	5 7596	2.6398	10	15 1844	18.3476
11	6.0214	3.8852	11	15.4462	18.9858
2 *ft.*	6.2832	3.1416	5 *ft.*	15.7080	19.6350
1	6.5450	3.4087	1	15.9698	20.2947
2	6.8068	3.6869	2	16.2316	20.9656
3	7.0686	3.9760	3	16.4934	21.6475
4	7.3304	4.2760	4	16.7552	22.3400
5	7.5922	4.5869	5	17.0170	23.0437
6	7.8540	4.9087	6	17.2788	23.7583
7	8.1158	5.2413	7	17.5406	24.4835
8	8 3776	5.5850	8	17.8024	25 2199
9	8.6394	5.9395	9	18.0642	25.9672
10	8.9012	6.3049	10	18.3260	26.7251
11	9.1630	6.6813	11	18.5878	27.4943
3 *ft.*	9.4248	7.0686	6 *ft.*	18.8496	28.2744
1	9.6866	7.4666	1	19.1114	29.0649
2	9.9484	7.8757	2	19.3732	29.8668
3	10.2102	8 2957	3	19.6350	30.6796
4	10.4720	8 7265	4	19.8968	31.5029
5	10.7338	9.1683	5	20.1586	32.3376
6	10 9956	9.6211	6	20.4204	33.1831
7	11.2574	10.0846	7	20.6822	34.0391
8	11.5192	10.5591	8	20.9440	34.9065
9	11.7810	11.0446	9	21.2058	35.7847
10	12.0428	11.5409	10	21.4676	36.6735
11	12.3046	12.0481	11	21.7294	37.5736

Diam.	Circum.	Area.	Diam.	Circum.	Area.
7 *ft.*	21.9912	38.4846	11 *ft.*	34.5576	95.0334
1	22.2530	39.4060	1	34.8194	96.4783
2	22.5148	40.3388	2	35.0812	97.9347
3	22.7766	41.2825	3	35.3430	99.4021
4	23.0384	42.2367	4	35.6048	100.8797
5	23.3002	43.2022	5	35.8666	102.3689
6	23.5620	44.1787	6	36.1284	103.8691
7	23.8238	45.1656	7	36.3902	105.3794
8	24.0856	46.1638	8	36.6520	106.9013
9	24.3474	47.1730	9	36.9138	108.4342
10	24.6092	48.1926	10	37.1756	109.9772
11	24.8710	49.2236	11	37.4374	111.5319
8 *ft.*	25.1328	50.2656	12 *ft.*	37.6992	113.0976
1	25.3946	51.3178	1	37.9610	114.6732
2	25.6564	52.3816	2	38.2228	116.2607
3	25.9182	53.4562	3	38.4846	117.8590
4	26.1800	54.5412	4	38.7464	119.4674
5	26.4418	55.6377	5	39.0082	121.0876
6	26.7036	56.7451	6	39.2700	122.7187
7	26.9654	57.8628	7	39.5318	124.3598
8	27.2272	58.9920	8	39.7936	126.0127
9	27.4890	60.1321	9	40.0554	127.6765
10	27.7508	61.2826	10	40.3172	129.3504
11	28.0126	62.4445	11	40.5790	131.0360
9 *ft.*	28.2744	63.6174	13 *ft.*	40.8408	132.7326
1	28.5362	64.8006	1	41.1026	134.4391
2	28.7980	65.9951	2	41.3644	136.1574
3	29.0598	67.2007	3	41.6262	137.8867
4	29.3216	68.4166	4	41.8880	139.6260
5	29.5834	69.6440	5	42.1498	141.3771
6	29.8452	70.8823	6	42.4116	143.1391
7	30.1070	72.1309	7	42.6734	144.9111
8	30.3688	73.3910	8	42.9352	146.6949
9	30.6306	74.6620	9	43.1970	148.4896
10	30.8924	75.9433	10	43.4588	150.2943
11	31.1542	77.2362	11	43.7206	152.1109
10 *ft.*	31.4160	78.5400	14 *ft.*	43.9824	153.9384
1	31.6778	79.8540	1	44.2442	155.7758
2	31.9396	81.1795	2	44.5060	157.6250
3	32.2014	82.5160	3	44.7678	159.4852
4	32.4632	83.8627	4	45.0296	161.3553
5	32.7250	85.2211	5	45.2914	163.2373
6	32.9868	86.5903	6	45.5532	165.1303
7	33.2486	87.9697	7	45.8150	167.0331
8	33.5104	89.3608	8	46.0768	168.9479
9	33.7722	90.7627	9	46.3386	170.8735
10	34.0340	92.1749	10	46.6004	172.8091
11	34.2958	93.5986	11	46.8622	174.7565

Diam.	Circum.	Area.	Diam.	Circum.	Area.
15 *ft.*	47.1240	176.7150	19 *ft.*	59.6904	283.5294
1	47.3858	178.6832	1	59.9522	286.0210
2	47.6476	180.6634	2	60.2140	288.5249
3	47.9094	182.6545	3	60.4758	291.0397
4	48.1712	184.6555	4	60.7376	293.5641
5	48.4330	186.6684	5	60.9994	296.1007
6	48.6948	188.6923	6	61.2612	298.6483
7	48.9566	190.7260	7	61.5230	301.2054
8	49.2184	192.7716	8	61.7848	303.7747
9	49.4802	194.8282	9	62.0466	306.3550
10	49.7420	196.8946	10	62.3084	308.9448
11	50.0038	198.9730	11	62.5702	311.5469
16 *ft.*	50.2656	201.0624	20 *ft.*	62.8320	314.1600
1	50.5274	203.1615	1	63.0938	316.7824
2	50.7892	205.2726	2	63.3556	319.4173
3	51.0510	207.3946	3	63.6174	322.0630
4	51.3128	209.5264	4	63.8792	324.7182
5	51.5746	211.6703	5	64.1410	327.2858
6	51.8364	213.8251	6	64.4028	330.0643
7	52.0982	215.9896	7	64.6646	332.7522
8	52 3600	218.1662	8	64.9264	335.4525
9	52 6218	220.3537	9	65.1882	338.1637
10	52.8836	222.5510	10	65.4500	340.8844
11	53.1454	224.7603	11	65.7118	343.6174
17 *ft.*	53.4072	226.9806	21 *ft.*	65.9736	346.3614
1	53.6690	229.2105	1	66.2354	349.1147
2	53.9308	231.4525	2	66.4972	351.8804
3	54.1926	233.7055	3	66.7590	354.6571
4	54.4544	235.9682	4	67.0208	357.4432
5	54.7162	238.2430	5	67.2826	360.2417
6	54.9780	240.5287	6	67.5444	363.0511
7	55.2398	242.8241	7	67.8062	365.8698
8	55.5016	245.1316	8	68.0680	368.7011
9	55.7634	247.4500	9	68.3298	371.5432
10	56.0252	249.7781	10	68.5916	374.3947
11	56.2870	252.1184	11	68.8534	377.2587
18 *ft.*	56.5488	254.4696	22 *ft.*	69.1152	380.1336
1	56.8106	256.8303	1	69.3770	383.0177
2	57.0724	259.2033	2	69.6388	385.9144
3	57.3342	261.5872	3	69.9006	388.8220
4	57.5960	263.9807	4	70.1624	391.7389
5	57.8578	266.3864	5	70.4242	394.6683
6	58.1196	268.8031	6	70.6860	397.6087
7	58.3814	271.2293	7	70.9478	400.5583
8	58.6432	273.6678	8	71.2096	403.5204
9	58.9050	276.1171	9	71.4714	406.4935
10	59.1668	278.5761	10	71.7332	409.4759
11	59.4286	281.0472	11	71.9950	412.4707

Diam.	Circum.	Area.	Diam.	Circum.	Area.
23 *ft.*	72.2568	415.4766	27 *ft.*	84.8232	572.5566
1	72.5186	418.4915	1	85.0850	576.0949
2	72.7804	421.5192	2	85.3468	579.6463
3	73.0422	424.5577	3	85.6086	583.2085
4	73.3040	427.6055	4	85.8704	586.7796
5	73.5658	430.6658	5	86.1322	590.3637
6	73.8276	433.7371	6	86.3940	593.9587
7	74.0894	436.8175	7	86.6558	597.5625
8	74.3512	439.9106	8	86.9176	601.1793
9	74.6130	443.0146	9	87.1794	604.8070
10	74.8748	446.1278	10	87.4412	608.4436
11	75.1366	449.2536	11	87.7030	612.0931
24 *ft.*	75.3984	452.3904	28 *ft.*	87.9648	615.7536
1	75.6602	455.5362	1	88 2266	619.4228
2	75.9220	458.6948	2	88.4884	623.1050
3	76.1838	461.8642	3	88.7502	626.7982
4	76.4456	465.0428	4	89.0120	630.5002
5	76.7074	468.2341	5	89.2738	634.2152
6	76.9692	471.4363	6	89.5356	637.9411
7	77.2310	474.6476	7	89.7974	641.6758
8	77.4928	477.8716	8	90.0592	645.4235
9	77.7546	481.1065	9	90 3210	649.1821
10	78.0164	484.3506	10	90.5828	652.9495
11	78.2782	487.6073	11	90.8446	656 7300
25 *ft.*	78.5400	490.8750	29 *ft.*	91.1064	660.5214
1	78.8018	494.1516	1	91.3682	664.3214
2	79.0636	497.4411	2	91.6300	668.1346
3	79.3254	500.7415	3	91.8918	671.9587
4	79.5872	504.0510	4	92.1536	675.7915
5	79.8490	507.3732	5	92.4154	679.6375
6	80.1108	510.7063	6	92.6772	683.4943
7	80.3726	514.0484	7	92.9390	687.3598
8	80.6344	517.4034	8	93.2008	691.2385
9	80.8962	520.7692	9	93.4626	695.1280
10	81.1580	524.1441	10	93.7244	699.0263
11	81.4198	527.5318	11	93.9862	702.9377
26 *ft.*	81.6816	530.9304	30 *ft.*	94.2480	706.8600
1	81.9434	534.3379	1	94.5098	710.7909
2	82.2052	537.7583	2	94.7716	714.7350
3	82.4670	541.1896	3	95.0334	718.6900
4	82.7288	544.6299	4	95.2952	722.6537
5	82.9906	548.0830	5	95.5570	726.6305
6	83.2524	551.5471	6	95.8186	730.6183
7	83.5142	555.0201	7	96.0806	734.6147
8	83.7760	558.5059	8	96.3424	738.6242
9	84.0378	562.0027	9	96.6042	742.6447
10	84.2996	565.5084	10	96.8660	746.6738
11	84.5614	569.0270	11	97.1278	750.710

Diam.	Circum.	Area.	Diam.	Circum.	Area.
31 *ft.*	97.3896	754.7694	35 *ft.*	109.9560	962.1150
1	97.6514	758.8311	1	110.2178	966.7001
2	97.9132	762.9062	2	110.4796	971.2989
3	98.1750	766.9921	3	110.7414	975.9085
4	98.4368	771.0866	4	111.0032	980.5264
5	98.6986	775.1944	5	111.2650	985.1579
6	98.9604	779.3131	6	111.5268	989.8003
7	99.2222	783.4403	7	111.7886	994.4509
8	99.4840	787.5808	8	112.0504	999.1151
9	99.7458	791.7322	9	112.3122	1003.7902
10	100.0076	795.8922	10	112.5740	1008.4736
11	100.2694	800.0654	11	112.8358	1013.1705
32 *ft.*	100.5312	804.2496	36 *ft.*	113.0976	1017.8784
1	100.7930	808.4422	1	113.3594	1022.5944
2	101.0548	812.6481	2	113.6212	1027.3240
3	101.3166	816.8650	3	113.8830	1032.0646
4	101.5784	821.0904	4	114.1448	1036.8134
5	101.8402	825.3291	5	114.4066	1041.5758
6	102.1020	829.5787	6	114.6684	1046.3491
7	102.3638	833.8368	7	114.9302	1051.1306
8	102.6256	838.1082	8	115.1920	1055.9257
9	102.8874	842.3905	9	115.4538	1060.7317
10	103.1492	846.6813	10	115.7756	1065.5459
11	103.4110	850.9855	11	115.9774	1070.3738
33 *ft.*	103.6728	855.3006	37 *ft.*	116.2392	1075.2126
1	103.9346	859.6240	1	116.5010	1080.0594
2	104.1964	863.9609	2	116.7628	1084.9201
3	104.4582	868.3087	3	117.0246	1089.7915
4	104.7200	872.6649	4	117.2864	1094.6711
5	104.9818	877.0346	5	117.5482	1099.5644
6	105.2436	881.4151	6	117.8100	1104.4687
7	105.5054	885.8040	7	118.0718	1109.3810
8	105.7672	890.2064	8	118.3336	1114.3071
9	106.0290	894.6196	9	118.5954	1119.2440
10	106.2908	899.0413	10	118.8572	1124.1891
11	106.5526	903.4763	11	119.1190	1129.1478
34 *ft.*	106.8144	907.9224	38 *ft.*	119.3808	1134.1176
1	107.0762	912.3767	1	119.6426	1139.0953
2	107.3380	916.8445	2	119.9044	1144.0868
3	107.5998	921.3232	3	120.1662	1149.0892
4	107.8616	925.8103	4	120.4280	1154.0997
5	108.1234	930.3108	5	120.6898	1159.1239
6	108.3852	934.8223	6	120.9516	1164.1591
7	108.6470	939.3421	7	121.2134	1169.2023
8	108.9088	943.8753	8	121.4752	1174.2592
9	109.1706	948.4195	9	121.7370	1179.3271
10	109.4324	952.9720	10	121.9988	1184.4030
11	109.6942	957.5380	11	122.2606	1189.4927

Diam.	Circum.	Area.	Diam.	Circum.	Area.
39 *ft.*	122.5224	1194.5934	43 *ft.*	135.0388	1452.2046
1	122.7842	1199.7195	1	135.3506	1457.8365
2	123.0460	1204.8244	2	135.6124	1463.4827
3	123.3078	1209.9577	3	135.8742	1469.1397
4	123.5696	1215.0990	4	136.1360	1474.8044
5	123.8314	1220.2542	5	136.3978	1480.4833
6	124.0932	1225.4203	6	136.6596	1486.1731
7	124.3550	1230.5943	7	136.9214	1491.8705
8	124.6168	1235.7822	8	137.1832	1497.5821
9	124.8786	1240.9810	9	137.4450	1503.3046
10	125.1404	1246.1878	10	137.7068	1509.0348
11	125.4022	1251.4084	11	137.9686	1514.7791
40 *ft.*	125.6640	1256.6400	44 *ft.*	138.2304	1520.5344
1	125.9258	1261.8794	1	138.4922	1526.2971
2	126.1876	1267.1327	2	138.7540	1532.0742
3	126.4494	1272.3970	3	139.0158	1537.8622
4	126.7112	1277.6692	4	139.2776	1543.6578
5	126.9730	1282.9553	5	139.5394	1549.4676
6	127.2348	1288.2523	6	139.8012	1555.2883
7	127.4966	1293.5572	7	140.0630	1561.1165
8	127.7584	1298.8760	8	140.3248	1566 9591
9	128.0202	1304.2057	9	140.5866	1572.8125
10	128.2820	1309.5433	10	140.8484	1578.6735
11	128.5438	1314.8949	11	141.1102	1584 5488
41 *ft.*	128.8056	1320.2574	45 *ft.*	141.3720	1590.4350
1	129.0674	1325.6276	1	141.6338	1596.3286
2	129.3292	1331.0119	2	141.8956	1602.2366
3	129.5910	1336.4071	3	142.1574	1608.1555
4	129.8528	1341.8101	4	142.4192	1614.0819
5	130.1146	1347.2271	5	142.6810	1620.0226
6	130.3764	1352.6551	6	142.9428	1625.9743
7	130.6382	1358.0908	7	143.2046	1631.9334
8	130.9000	1363.5406	8	143.4664	1637.9068
9	131.1618	1369.0012	9	143.7282	1643.8912
10	131.4236	1374.4697	10	143.9900	1649.8831
11	131.6854	1379.9521	11	144.2518	1655.8892
42 *ft.*	131.9472	1385.4456	46 *ft.*	144.5136	1661.9064
1	132.2090	1390.2467	1	144.7754	1667.9308
2	132.4708	1396.4619	2	145.0372	1673.9698
3	132.7326	1401 9880	3	145.2990	1680.0196
4	132.9944	1407.5219	4	145.5608	1686.0769
5	133.2562	1413.0698	5	145.8226	1692.1485
6	133.5180	1418.6287	6	146.0844	1698 2311
7	133.7798	1424.1952	7	146.3462	1704.3210
8	134.0416	1429.7759	8	146.6080	1710 4254
9	134.3034	1435.3675	9	146.8698	1716.5407
10	134.5652	1440.9668	10	147.1316	1722.6634
11	134.8270	1446.5802	11	147.3934	1728.8005

Diam.	Circum.	Area.	Diam.	Circum.	Area.
47 *ft.*	147.6552	1734.9486	48 7	152.6294	1853.8087
1	147.9170	1741.1039	8	152.8912	1860.1750
2	148.1788	1747.2738	9	153.1530	1866.5521
3	148.4406	1753.4545	10	153.4148	1872.9365
4	148.7024	1759.6426	11	153.6766	1879.3355
5	148.9642	1765.8452	49 *ft.*	153.9384	1885.7454
6	149.2260	1772.0587	1	154.2002	1892.1724
7	149.4878	1778.2795	2	154.4620	1898.5041
8	149.7496	1784.5148	3	154.7238	1905.0367
9	150.0114	1790.7610	4	154.9856	1911.4965
10	150.2732	1797.0145	5	155.2474	1917.9609
11	150.5350	1803.2826	6	155.5092	1924.4263
48 *ft.*	150.7968	1809.5616	7	155.7710	1930.9188
1	151.0586	1815.8477	8	156.0328	1937.3159
2	151.3204	1822.1485	9	156.2946	1943.9140
3	151.5822	1828.4602	10	156.5564	1950.4392
4	151.8440	1834.7791	11	156.8182	1956.9691
5	152.1058	1841.1127	50 *ft.*	157.0800	1963.5000
6	152.3676	1847.4571			

TABLE XI,

Containing the superficies and solid content of spheres, from 1 *to* 12, *and advancing by a tenth.*

Diam.	Superficies.	Solidity.	Diam.	Superficies.	Solidity.
1.0	3.1416	.5236	2.5	19.6350	8.1812
.1	3.8013	.6969	.6	21.2372	9.2027
.2	4.5239	.9047	.7	22.9022	10.3060
.3	5.3093	1.1503	.8	24.6300	11.4940
.4	6.1575	1.4367	.9	26.4208	12.7700
.5	7.0686	1.7671	3.0	28.2744	14.1372
.6	8.0424	2.1446	.1	30.1907	15.5985
.7	9.0792	2.5724	.2	32.1699	17.1573
.8	10.1787	3.0536	.3	34.2120	18.8166
.9	11.3411	3.5913	.4	36.3168	20.5795
2.0	12.5664	4.1888	.5	38.4846	22.4493
.1	13.8544	4.8490	.6	40.7151	24.4290
.2	15.2053	5.5752	.7	43.0085	26.5219
.3	16.6190	6.3706	.8	45.3647	28.7309
.4	18.0956	7.2382	.9	47.7837	31.0594

Diam.	*Superficies.*	*Solidity.*	*Diam.*	*Superficies.*	*Solidity.*
4.0	50.2656	33.5104	8.0	201.0624	268.0832
.1	52.8102	36.0870	.1	206.1203	278.2625
.2	55.4178	38.7924	.2	211.2411	288.6962
.3	58.0881	41.6298	.3	216.4248	299.3876
.4	60.8213	44.6023	.4	221.6712	310.3398
.5	63.6174	47.7130	.5	226.9806	321.5558
.6	66.4782	50.9651	.6	232.3527	333.0389
.7	69.3979	54.3617	.7	237.7877	344.7921
.8	72.3824	57.9059	.8	243.2855	356.8187
.9	75.4298	61.6010	.9	248.8461	369.1217
5.0	78.5400	65.4500	9.0	254.4696	381.7044
.1	81.7130	69.4560	.1	260.1558	394.5697
.2	84.9488	73.6223	.2	265.9130	407.7210
.3	88.2475	77.9519	.3	271.7169	421.1613
.4	91.6090	82.4481	.4	277.5917	434.8937
.5	95.0334	87.1139	.5	283.5294	448.9215
.6	98.5205	91.9525	.6	289.5298	463.2477
.7	102.0705	96.9670	.7	295.5931	477.7755
.8	105.6834	102.1606	.8	301.7192	492.8081
.9	109.3590	107.5364	.9	307.9082	508.0485
6.0	113.0976	113.0976	10.0	314.1600	523.6000
.1	116.8989	118.8472	.1	320.4746	539.4656
.2	120.7631	124.7885	.2	326.8520	555.6485
.3	124.6901	130.9246	.3	333.2923	572.1518
.4	128.6799	137.2585	.4	339.7954	588.9784
.5	132.7326	143.7936	.5	346.3614	606.1324
.6	136.8480	150.5329	.6	352.9901	623.6159
.7	141.0264	157.4795	.7	359.6817	641.4325
.8	145.2675	164.6365	.8	366.4362	659.5852
.9	149.5715	172.0073	.9	373.2534	678.0771
7.0	153.9384	179.5948	11.0	380.1336	696.9116
.1	158.3680	187.4021	.1	387.0765	716.0915
.2	162.8605	195.4326	.2	394.0823	735.6200
.3	167.4158	203.6893	.3	401.1509	755.5008
.4	172.0340	212.1752	.4	408.2823	775.7364
.5	176.7150	220.8937	.5	415.4766	796.3301
.6	181.4588	229.8478	.6	422.7336	817.2851
.7	186.2654	239.0511	.7	430.0536	838.6045
.8	191.1349	248.4754	.8	437.4363	860.2915
.9	196.0672	258.1552	.9	444.8819	882.3492
			12.0	452.3904	904.7808

TABLE XII,

Containing the squares, cubes, superficies, and solid content of spheres, from ½ inch to 12 inches, advancing by an eighth.

Diam.	Squares.	Cubes.	Superficies.	Solidity.
½	.25	.125	.7854	.0654
⅝	.390625	.244140625	1.2271	.1278
¾	.5625	.421875	1.7671	.2208
⅞	.765625	.669921875	2.4052	.3507
1 *in.*	1	1	3.1416	.5236
⅛	1.265625	1.423818125	3.9760	.7455
¼	1.5625	1.953125	4.9087	1.0226
⅜	1.890625	2.599609375	5.9395	1.3611
½	2.25	3.375	7.0686	1.7671
⅝	2.640625	4.291015625	8.2957	2.2467
¾	3.0625	5.359375	9.6211	2.8061
⅞	3.515625	6.591796875	11.0446	3.4514
2 *in.*	4	8	12.5664	4.1888
⅛	4.515625	9.595703125	14.1862	5.0243
¼	5.0625	11.390625	15.9043	5.9640
⅜	5.640625	13.39648375	17.7205	7.0143
½	6.25	15.625	19.6350	8.1812
⅝	6.890625	18.087890625	21.6475	9.4708
¾	7.5625	20.796875	23.7583	10.8892
⅞	8.265625	23.763671875	25.9672	12.4426
3 *in.*	9	27	28.2744	14.1372
⅛	9.765625	30.517578125	30.6796	15.9790
¼	10.5625	34.328125	33.1831	17.9742
⅜	11.390625	38.443359375	35.7847	20.1289
½	12.25	42.875	38.4846	22.4493
⅝	13.140625	47.634765625	41.2825	24.9415
¾	14.0625	52.734375	44.1787	27.6117
⅞	15.015625	58.185546875	47.1730	30.4659
4 *in.*	16	64	50.2656	33.5104
⅛	17.015625	70.189453125	53.4562	36.7511
¼	18.0625	76.765625	56.7451	40.1944
⅜	19.140625	83.740234375	60.1321	43.8463
½	20.25	91.125	63.6174	47.7127
⅝	21.390625	98.931640625	67.2007	51.8006
¾	22.5625	107.171875	70.8823	56.1151
⅞	23.765625	115.857421875	74.6620	60.6629
5 *in.*	25	125	78.5400	65.4500
⅛	26.265625	134.611328125	82.5160	70.4824
¼	27.5625	144.703125	86.5903	75.7664
⅜	28.890625	155.287109375	90.7627	81.3083
½	30.25	166.375	95.0334	87.1139
⅝	31.640625	177.978515625	99.4021	93.1875
¾	33.0625	190.109375	103.8691	99.5412
⅞	34.515625	202.779296875	108.4342	106.1754

Diam.	*Squares.*	*Cubes.*	*Superficies.*	*Solidity.*
6 *in.*	36	216	113.0976	113.0976
⅛	37.515625	229.783203115	117.8590	120.3139
¼	39.0625	244.140625	122.7187	127.8320
⅜	40.640625	259.083984375	127.6765	135.6563
½	42.25	274.625	132.7326	143.7936
⅝	43.890625	290.775390625	137.8867	152.2499
¾	45.5625	307.546875	143.1391	161.0315
⅞	47.265625	324.951171875	148.4896	170.1682
7 *in.*	49	343	153.9384	179.5948
⅛	50.765625	361.704078125	159.4852	189.3882
¼	52.5625	381.078125	165.1303	199.5325
⅜	54.390625	401.130859375	170.8735	210.0331
½	56.25	421.875	176.7150	220.8937
⅝	58.140625	443.322265625	182.6545	232.1235
¾	60.0625	465.484375	188.6923	243.7276
⅞	62.015625	488.373046875	194.8282	255.7121
8 *in.*	64	512	201.0624	268.0832
⅛	66.015625	536.376953125	207.3946	280.8469
¼	68.0625	561.515625	213.8251	294.0095
⅜	70.140625	587.427734375	220.3537	307.5771
½	72.25	614.125	226.9806	321.5553
⅝	74.390625	641.619140625	233.7055	335.9517
¾	76.5625	669.921875	240.5287	350.7710
⅞	78.765625	699.044921875	247.4500	366.0199
9 *in.*	81	729	254.4696	381.7017
⅛	83.265625	759.798828125	261.5872	397.8306
¼	85.5625	791.453125	268.8031	414.4048
⅜	87.890625	823.974609375	276.1171	431.4361
½	90.25	857.375	283.5294	448.9215
⅝	92.640625	891.666015625	291.0397	466.8763
¾	95.0625	926.859375	298.6483	485.3035
⅞	97.515625	962.966796875	306.3550	504.2094
10 *in.*	100	1000	314.1600	523.6000
⅛	102.515625	1037.970703125	322.0630	543.4814
¼	105.0625	1076.890625	330.0643	563.8603
⅜	107.640625	1116.771448375	338.1637	584.7415
½	110.25	1157.625	346.3614	606.1318
⅝	112.890625	1199.462890625	354.6571	628.0387
¾	115.5625	1242.296875	363.0511	650.4666
⅞	118.265625	1286.138671875	371.5432	673.4222
11 *in.*	121	1331	380.1336	696.9116
⅛	123.765625	1376.892578125	388.8220	720.9409
¼	126.5625	1423.828125	397.6087	745.5004
⅜	129.390625	1471.818359375	406.4935	770.6440
½	132.25	1520.875	415.4766	796.3301
⅝	135.140625	1571.009765625	424.5576	822.5807
¾	138.0625	1622.234375	433.7371	849.4035
⅞	141.015625	1674.560546875	443.0146	876.7999
12 *in.*	144	1728	452.3904	904.7809

Formation of the preceding Tables.

In calculating the preceding tables of circumferences, squares, cubes, areas, &c., the following simple rules have been adopted:—

1. *The circumferences.*

The circumferences were obtained by adding $\frac{1}{8}$ of 3.1416, or .3927 constantly for the first table; $\frac{1}{10}$ of 3.1416, or .31416 for the second; and $\frac{1}{12}$ or .2618 for the third table; thus,

The circumference of a circle, whose diameter is

	1	= 3.1416
		+ .3927
	$1\frac{1}{8}$	= 3.5343
		+ .3927
	$1\frac{1}{4}$	= 3.9270
		+ .3927
	$1\frac{3}{8}$	= 4.3197, &c.
Again,	1	= 3.1416
		+ .31416
	1.1	= 3 45576
		+ .31416
	1.2	= 3.76992
		+ .31416
	1.3	= 4.08408, &c.
Also,	1 foot	= 3.1416
		+ .2618
	1.0833	= 3.4034
		+ .2618
	1.1666	= 3.6652
		+ .2618
	1.25	= 3.9270, &c.

2. *The squares.*

After the first square of each succeeding series was found by the common rule, twice the root of that square, plus 1, added to the square number obtained, gave the square of the next number required; thus,

The square of		1.1 = 1.21	
And	1.1 × 2 + 1 =	3.2 +	
		4.41	= the square of 2.1
	2.1 × 2 + 1 =	5.2 +	
		9.61	= the square of 3.1
	3.1 × 2 + 1 =	7.2 +	
		16.81	= the square of 4.1, &c.

Again the square of 1.2 =		1.44	
And	1.2 × 2 + 1 =	3.4 +	
		4.84	= the square of 2.2
	2.2 × 2 + 1 =	5.4 +	
		10.24	= the square of 3.2
	3.2 × 2 + 1 =	7.4 +	
		17.64	= the square of 4.2, &c.

3. *The cubes.*

In finding the cubes, the first of each series was also found in the usual form, then the root of the number so obtained being multiplied by 3, and by the root of the number required, and the product, plus 1, added to the former cube, gave the cube of the next number required; thus,

	The cube of 1.1 =	1.331	
And	1.1 × 3 × 2.1 + 1 =	7.93 +	
		9.261	= the cube of 2.1
	2.1 × 3 × 3.1 + 1 =	20.53 +	
		29.791	= the cube of 3.1
	3.1 × 3 × 4.1 + 1 =	39.13 +	
		68.921	= the cube of 4.1, &c.

Or the cube of 1.2 = 1.728
And $1.2 \times 3 \times 2.2 + 1 = 8.92 +$
10.648 = the cube of 2.2
$2.2 \times 3 \times 3.8 + 1 = 22.12 +$
32.768 = the cube of 3.2
$3.2 \times 3 \times 4.2 + 1 = 41.32 +$
74.088 = the cube of 4.2, &c.

4. *The areas.*

After the first area of each succeeding series was obtained by the common rule, the others were found by the following, namely, a table of constant numbers was formed by multiplying .7854 by twice the fractional number contained in the diameter; thus,

$\frac{1}{8} \times 2 = .25 \times .7854 = .19635$
$\frac{1}{4} \times 2 = .5 \times .7854 = .3927$
$\frac{3}{8} \times 2 = .75 \times .7854 = .58905$
$\frac{1}{2} \times 2 = 1 \times .7854 = .7854$
$\frac{5}{8} \times 2 = 1.25 \times .7854 = .98175$
$\frac{3}{4} \times 2 = 1.5 \times .7854 = 1.1781$
$\frac{7}{8} \times 2 = 1.75 \times .7854 = 1.37445$ for the first table.

$.1 \times 2 = .2 \times .7854 = .15708$
$.2 \times 2 = .4 \times .7854 = .31416$
$.3 \times 2 = .6 \times .7854 = .47124$
$.4 \times 2 = .8 \times .7854 = .62832$
$.5 \times 2 = 1 \times .7854 = .7854$
$.6 \times 2 = 1.2 \times .7854 = .94248$
$.7 \times 2 = 1.4 \times .7854 = 1.09956$
$.8 \times 2 = 1.6 \times .7854 = 1.25664$
$.9 \times 2 = 1.8 \times .7854 = 1.41372$ for the second.

And, $.0833 \times 2 = .1666 \times .7854 = .13084764$
$.1666 \times 2 = .3333 \times .7854 = .26177382$
$.25 \times 2 = .5 \times .7854 = .3927$
$.3333 \times 2 = .6666 \times .7854 = .52354764$
$.4166 \times 2 = .8333 \times .7854 = .165447382$
$.5 \times 2 = 1 \times .7854 = .7854$
$.5833 \times 2 = 1.1666 \times .7854 = .91624764$
$.6666 \times 2 = 1.3333 \times .7854 = 1.04717382$
$.75 \times 2 = 1.5 \times .7854 = 1.1781$
$.8333 \times 2 = 1.6666 \times .7854 = 1.30894764$
$.9166 \times 2 = 1.8333 \times .7854 = 1.43987382$ for the third table, &c.

Then twice the whole numbers of the first circle plus 1, and multiplied by .7854, produced a sum which, when added to the area and constant number of the fractional part, gave the area of the next in the series; thus,

The area of a circle whose diameter is $1\frac{1}{8}$
$= .994021875$
And $1 \times 2 + 1 = 3 \times .7854 = 2.3562$
+the constant number $.19635$

3.546571875 = the area of $2\frac{1}{8}$

$2 \times 2 + 1 = 5 \times .7854 = 3.927$
$+ .19635$

7.669921875 = the area of $3\frac{1}{8}$

$3 \times 2 + 1 = 7 \times .7854 = 5.4978$
$+ .19635$

13.364071875 = the area of $4\frac{1}{8}$, &c.

Again, the area of $1\frac{1}{4} = 1.2271875$
To which add as above, 2.3562
And the constant number $.3927$

3.9760875 = the area of $2\frac{1}{4}$.
3.927
$.3927$

8.2957875 = the area of $3\frac{1}{4}$.
5.4978
$.3927$

14.1862875 = the area of $4\frac{1}{4}$, &c.

DECIMAL EQUIVALENTS TO FRACTIONAL PARTS OF LINEAL MEASURES.

One inch, the integer or whole number.

.96875	are equal to	& 31/32	.625	are equal to	& 5/8	.28125	are equal to	& 9/32
.9375		& 15/16	.59375		& 19/32	.25		
.90625		& 29/32	.5625		& 9/16	.21875		& 7/32
.875		& 7/8	.53125		& 17/32	.1875		& 3/16
.84375		& 27/32	.5		& 1/2	.15625		& 5/32
.8125		& 13/16	.46875		& 15/32	.125		
.78125		& 25/32	.4375		& 7/16	.09375		3/32
.75		& 3/4	.40625		& 13/32	.0625		1/16
.71875		& 23/32	.375		& 3/8	.03125		1/32
.6875		& 11/16	.34375		& 11/32			
.65625		& 21/32	.3125		& 5/16			

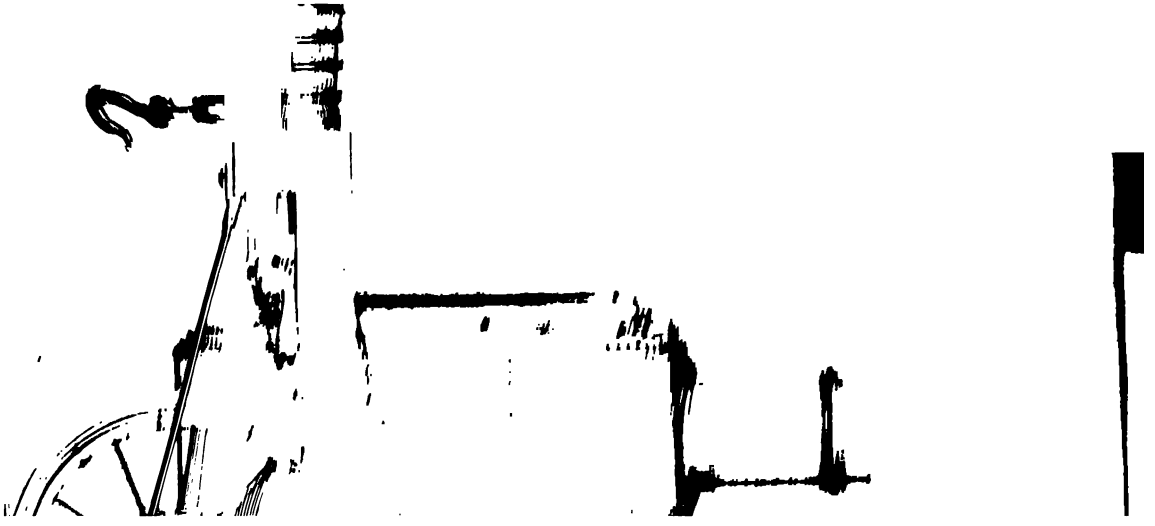
One foot, or 12 inches, the integer.

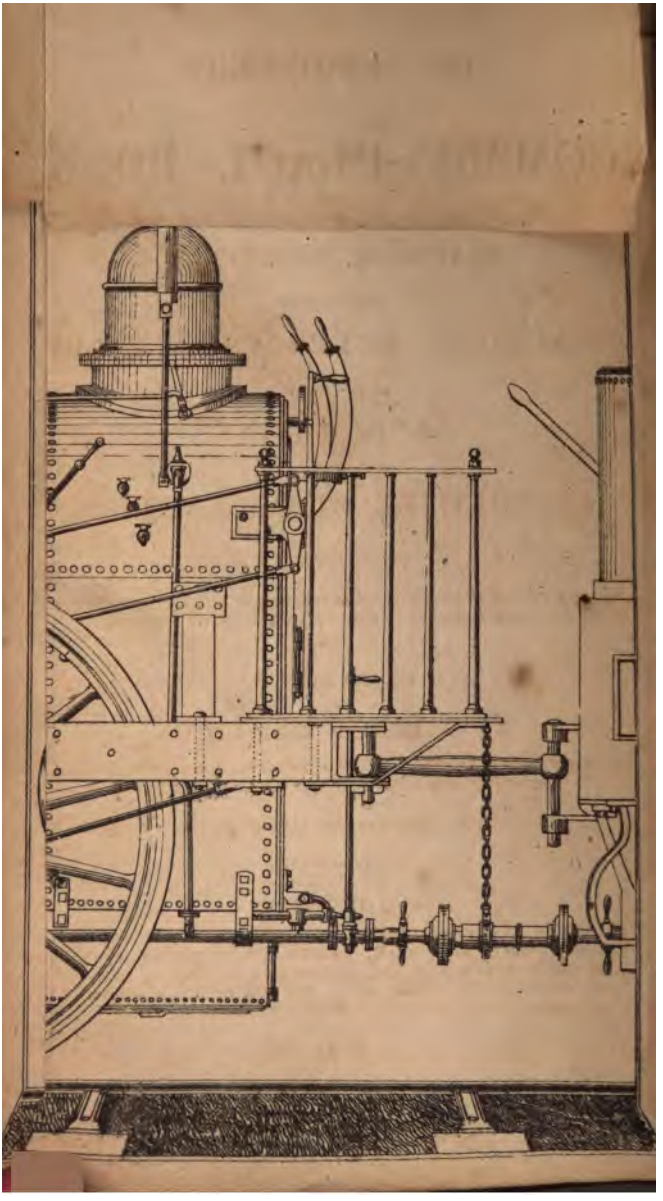
.9166	are equal to	11 inches.	.4166	are equal to	5 in.	.0625	are equal to	of in.
.6333		10 „	.3333		4 „	.0528		„
.75		9 „	.25		3 „	.04166		„
.6666		8 „	.1666		2 „	.03125		„
.5833		7 „	.0833		1 „	.02083		„
.5		6 „	.07291		7/8 „	.01041		„

One yard, or 36 inches, the integer.

.9722	are equal to	35 inches.	.6389	are equal to	23 inches.	.3055	are equal to	11 inches.
.9445		34 „	.6111		22 „	.2778		10 „
.9167		33 „	.5833		21 „	.25		9 „
.8889		32 „	.5556		20 „	.2222		8 „
.8611		31 „	.5278		19 „	.1944		7 „
.8333		30 „	.5		18 „	.1666		6 „
.8056		29 „	.4722		17 „	.1389		5 „
.7778		28 „	.4445		16 „	.1111		4 „
.75		27 „	.4166		15 „	.0833		3 „
.7222		26 „	.3889		14 „	.0555		2 „
.6944		25 „	.3611		13 „	.0277		1 „
.6667		24 „	.3333		12 „			

SMITH, ROGERSON, AND CO., PRINTERS, LIVERPOOL.





THE ENGINEER'S

COMMON-PLACE BOOK

OF

PRACTICAL REFERENCE,

CONSISTING OF

PRACTICAL RULES AND TABLES

ADAPTED TO

LAND, MARINE,

AND

LOCOMOTIVE STEAM-ENGINES,

TO WHICH IS ADDED,

SQUARE AND CUBE ROOTS OF NUMBERS, AREAS AND CIRCUMFERENCES OF CIRCLES, SUPERFICIES AND SOLIDITIES OF SPHERES, &c. &c. &c.

SECOND EDITION.

BY WILLIAM TEMPLETON,

Author of "The Millwright and Engineer's Pocket Companion," "Locomotive Engine Popularly Explained," and "Mathematical Tables."

WITH LITHOGRAPHIC ILLUSTRATIONS.

LONDON:

PUBLISHED BY SIMPKIN, MARSHALL, AND CO., STATIONERS'-HALL-COURT; SOLD ALSO BY G. HEBERT, 88, CHEAPSIDE, LONDON; EGERTON SMITH AND CO., LIVERPOOL; J. AND J. THOMSON, MANCHESTER; W. CURRY, JUN. AND CO., DUBLIN; BLACK AND CO., EDINBURGH; AND BY ALL BOOKSELLERS.

1841.

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ENTERED AT STATIONERS' HALL.

ADVERTISEMENT.

Popular works upon the steam-engine have become so numerous of late, that it might be supposed any attempt at farther illustration would only be an unnecessary repetition of former matter; and that, if possessed of any one work upon the subject, another is not required. Such, however, is not the case, for as improvements advance, so must corresponding calculations follow, deduced from those improvements, which cannot otherwise be so effectually obtained, because any rule to be made practically useful must be divested as much as possible of theory, and the more explicit a rule is the more generally useful it will prove to the practical engineer.

Having, in the course of my own practical employment, been frequently in want of ready practical rules connected with the steam-engine, and as often disappointed, after referring to works in which the required information might be expected, I was, in consequence, compelled to form rules from those engines which I found doing the greatest amount of duty at the least possible expense: hence, the following pages will be found chiefly to consist of those practical rules connected with the steam-engine in most of its various departments of application, and entirely divested of all speculative matter, by which the work might have been

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very considerably increased in bulk, but, in proportion, its value as greatly diminished.

I also found, in practice, that rules were much easier obtained and remembered when in the algebraic than in the arithmetical form; and knowing that it is now becoming more familiar as a science of numbers, I have been induced to give the greater part of the rules in the one form, and the examples in the other, so that the work might be rendered, not only a book of daily reference upon the steam-engine, but also the means of acquiring mathematical knowledge, as applicable to any other subject in which demonstration is required.

In the locomotive department I have been rather explicit, as it is the latest application of the steam-engine, and also my present practical employment, but I trust the work will be found generally useful, and particularly to those connected with either stationary, marine, or locomotive steam engines.

Leeds and Selby Railway,
Leeds, April, 1839.

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THE PRACTICAL

ENGINEER'S COMMON-PLACE BOOK, &c.

ALGEBRAIC SIGNS,

AS APPLIED IN MECHANICAL CALCULATIONS.

= Sign of Equality, and signifies equal to .....as 3 added to 4 = 7.

\+ Addition.....plus, or more.....5 + 3 = 8.

− Subtraction .....minus, or less .....8 − 3 = 5.

× Multiplication .....multiplied by .....8 × 3 = 24.

÷ Division.....divided by...24 ÷ 4 = 6, or $\frac{24}{4} = 6$.

∶ ∷ ∶ Proportion .....that 2 is to 3 as 4 is to 6.

$\surd$ Square Root } .....Evolution, or the extraction of roots,
$\sqrt[3]{}$ Cube root } thus, $\surd 64 = 8$, and $\sqrt[3]{64} = 4$.

4^2 to be squared } .....Involution, or the raising of powers,
4^3 to be cubed } thus, $4^2 = 16$, and $4^3 = 64$.

$\overline{3 + 5 \times 4} = 32$ .....that 3 plus 5 multiplied by 4 = 32.

$\surd \overline{5^2 - 3^2} = 4$...5 squared, minus 3 squared, the square root of the remainder = 4.

$\frac{\sqrt[3]{\overline{20 \times 12}}}{30} = 2$...20, multiplied by 12, and divided by 30, the cube root of the quotient = 2.

$\frac{\overline{24 \times 6} + \overline{12 \times 3} \times 4}{12} = 60$...24 multiplied by 6, and 12 multiplied by 3, added together, multiplied by 4 and divided by 12, the quotient = 60.

$\frac{A \; V \; Q}{n \; l} = d$...that A, V, and Q, multiplied together, and divided by n multiplied by l, the quotient = d.

$\frac{\overline{P - p} \times d}{W} = D$... P minus p multiplied by d, and divided by W = D

$S = \frac{V \; \overline{[(q \; M + F) \; D + p \; d^2 \; l]}}{m \; P \; D}$...$q$ multiplied by M, plus F, and multiplied by D, plus p, multiplied by d squared, and by l, the whole sum multiplied by V, and divided by the product of m P D, the quotient = S.

IMPERIAL STANDARD MEASURES.

1. MEASURE OF LENGTH.

Inches.					
12	1 foot.				
36	3	1 yard.			
198	$16\frac{1}{2}$	$5\frac{1}{2}$	1 pole or perch.		
7920	660	220	40	1 furlong.	
63360	5280	1760	320	8	1 mile.

The French metre or Standard measure of length = 39.371 in.

SPECIAL MEASURES OF LENGTH.

Nautical Measure.		*Land Measure.*	
1 nautical mile	= 6082.66 ft.	7.92 inches	= 1 link.
3 miles	= 1 league.	100 links	= 1 chain.
20 leagues	= 1 degree.	80 chains	= 1 mile.
360 degrees	= earth's cir.	69.121 miles	= 1 geo. deg.

6 feet = 1 fathom, used in measuring ropes, chains, &c.

A Table of the common fractional parts of an inch and a foot, with their corresponding decimals.

Fractions of an inch.	*Decimals.*	*Fractions of an inch.*	*Decimals.*	*Fractions of a foot or inches.*	*Decimals.*
$\frac{1}{8}$ & $\frac{3}{32}$	= .96875	$\frac{3}{8}$ & $\frac{3}{32}$	= .46875	11 =	.9166
$\frac{7}{8}$ & $\frac{1}{16}$	= .9375	$\frac{3}{8}$ & $\frac{1}{16}$	= .4375	10 =	.8333
$\frac{7}{8}$ & $\frac{1}{32}$	= .90625	$\frac{3}{8}$ & $\frac{1}{32}$	= .40625	9 =	.75
$\frac{7}{8}$	= .875	$\frac{3}{8}$	= .375	8 =	.6666
$\frac{3}{4}$ & $\frac{3}{32}$	= .84375	$\frac{1}{4}$ & $\frac{3}{32}$	= .34375	7 =	.5833
$\frac{3}{4}$ & $\frac{1}{16}$	= .8125	$\frac{1}{4}$ & $\frac{1}{16}$	= .3125	6 =	.5
$\frac{3}{4}$ & $\frac{1}{32}$	= .78125	$\frac{1}{4}$ & $\frac{1}{32}$	= .28125	5 =	.4166
$\frac{3}{4}$	= .75	$\frac{1}{4}$	= .25	4 =	.3333
$\frac{5}{8}$ & $\frac{3}{32}$	= .71875	$\frac{1}{8}$ & $\frac{3}{32}$	= .21875	3 =	.25
$\frac{5}{8}$ & $\frac{1}{16}$	= .6875	$\frac{1}{8}$ & $\frac{1}{16}$	= .1875	2 =	.1666
$\frac{5}{8}$ & $\frac{1}{32}$	= .65625	$\frac{1}{8}$ & $\frac{1}{32}$	= .15625	1 =	.0833
$\frac{5}{8}$	= .625	$\frac{1}{8}$	= .125	$\frac{7}{8}$ =	.07291
$\frac{1}{2}$ & $\frac{3}{32}$	= .59375	— $\frac{3}{32}$	= .09375	$\frac{3}{4}$ =	.0625
$\frac{1}{2}$ & $\frac{1}{16}$	= .5625	— $\frac{1}{16}$	= .0625	$\frac{5}{8}$ =	.0528
$\frac{1}{2}$ & $\frac{1}{32}$	= .53125	— $\frac{1}{32}$	= .03125	$\frac{1}{2}$ =	.04166
$\frac{1}{2}$	= .5			$\frac{3}{8}$ =	.03125
				$\frac{1}{4}$ =	.02083
				$\frac{1}{8}$ =	.01041

2. MEASURE OF SURFACE.

Inches.							
144	1 square foot.						
1296	9	1 square yard.					
39204	272¼.....	30¼.....	1 square pole.				
1568160	10890	1210	40	1 rood.			
6272640	43560	4840	160	4	1 acre.		

SPECIAL MEASURES OF SURFACE.

Land Measure.

62.7264 square inches = 1 square link,
10000 „ = 1 „ chain, and
10 square chains = 1 acre.

3. MEASURES OF CAPACITY.

General Measure of Solidity.

1728 cubic inches = 1 cubic foot.
27 cubic feet = 1 cubic yard.
42 cubic feet = 1 ton of shipping.

4. IMPERIAL GALLON MEASURE FOR LIQUIDS, CORN, &c.

Cubic inches.	water lbs. av.						
8.665	$\frac{5}{8}$	1 gill.					
34.659	1¼	4 ...	1 pint.				
69.318	2½	8 ...	2 ...	1 qrt.			
277.274	10	32 ...	8 ...	4 ...	1 gal.		
554.548	20	64 ...	16 ...	8 ...	2 ...	1 peck.	
2218.19	80	256 ...	64 ...	32 ...	8 ...	4 ...	1 bshl.
17745.5	640	2048 ...	512 ...	256 ...	64 ...	32 ..	8 ... 1 qr.

The peck, bushel, and quarter, are used for dry goods only.

1 gallon of sea water = 10.32 lbs. avoir.
1 „ oil = 9.32 „
1 „ proof spirits = 9.3 „
1 bushel of wheat = 60 „
1 „ barley = 47 „
1 „ oats = 38 „

The old ale gallon contained 282 cubic inches; and
The old wine gallon 231.

The French litre, or standard measure of capacity for liquids, contains 61.028 cubic inches, or about .453 of our imperial gallon.

5. IMPERIAL MEASURE OF CAPACITY FOR COALS, CULM, LIME, FRUIT, &c.

351.9375 cubic inches	1 gallon.
703.875	2 ... 1 peck.
2815.5	8 ... 4 ... 1 bushel.
4.888 cubic feet	24 ... 12 ... 3 ... 1 sack.
58.656	288 ... 144 ... 36 ... 12 ... 1 chaldron.

In and about London coals are sold by the cwt., ton, &c., but in Yorkshire, and many other places, they are sold by the bag, and estimated as follows:—

1 bag = 2 bushels, and weighs about 140lbs.
16 bags = 1 ton, and 24 bags = 1 chaldron, or 30 cwt.

A keel of coals at Newcastle is 21 tons 4 cwt., and a chaldron 53 cwt. A chaldron of coals in London is 28½ cwt.

6. AVOIRDUPOIS WEIGHT.

Troy Grains.	
27.34375	1 dram.
437.5	16 ... 1 ounce.
7000	256 ... 16 ... 1 lb.
98000	3584 ... 224 ... 14 ... 1 stone.
196000	7168 ... 448 ... 28 ... 2 ... 1 quarter.
784000	28672 ... 1792 ... 112 ... 8 ... 4 ... 1 cwt.
15680000	573440 ... 35840 ... 2240 ... 160 ... 80 ... 20 ... 1 ton.

The French gramme, or standard measure of weight, equal 15.434 troy grains, and the kilogramme 2.20486 lbs. avoir.

About	426	cubic inches of cast iron	= 1 cwt.
	8520	„ or	
nearly	5	cubic feet	= 1 ton.
	13	„ of stone	= 1 ton.
	23	„ sand	= 1 ton.
	29	„ coal	= 1 ton.
	38	„ tallow	= 1 ton.
	39	„ oil	= 1 ton.
	40	„ timber	= 1 ton.
	36	„ com. water	= 1 ton.
	35	„ sea water	= 1 ton.

Table of Specific Gravities.

NAMES OF BODIES.	Weight of a cubic foot in lbs.	Weight of a cubic in. in ounces.	Number of cubic inches in a lb.	Weight of a cubic inch in lbs.
Copper, cast	549.25	5.086	3.146	.3178
Copper, sheet	557.18	5.159	3.103	.3225
Brass, cast	524.75	4.852	3.223	.3037
Iron, cast	454.43	4.203	3.802	.263
Iron, bar	476.93	4.410	3.623	.276
Lead	709.00	6.456	2.437	.4103
Steel, soft	489.56	4.527	3.530	.2833
Steel, hard	488.50	4.517	3.537	.2827
Zinc, cast	449.37	4.156	3.845	.26
Tin, cast	455.75	4.215	3.790	.2636
Bismuth	619.50	5.710	2.789	.3585
Gun metal	549.00	5.077	3.147	.3177
Sand	95.00	.878	18.190	.055
Coal	78.12	.722	22.120	.0452
Brick	125.00	1.156	13.824	.0723
Stone, paving	151.00	1.396	11.443	.0873
Marble	171.37	1.585	10.083	.0991
Glass	180.00	1.664	9.600	.1042
Tallow	59.06	.546	29.258	.0342
Cork	15.00	.138	115.200	.0087
Oak	60.62	.561	28.505	.0351
Pine, pitch	41.25	.382	41.890	.024
Ash	47.50	.440	36.370	.0275
Spirits, proof	57.93	.536	29.828	.0335
Mercury	848.00	7.851	2.037	.4908

A Table of the specific gravity of water at different temperatures, that at 62 being taken as unity.

70° F.	.99913	52° F.	1.00076
68	.99936	50	1.00087
66	.99958	48	1.00095
64	.99980	46	1.00102
62	1.	44	1.00107
58	1.00035	42	1.00111
56	1.00050	40	1.00113
54	1.00064	33	1.00115

Note. The difference of temperatures between 62° and 42°, where water attains its greatest density, will vary the bulk of a gallon rather less than the third of a cubic inch.

WATER.

Water in an aeriform state constitutes the moving power of a steam-engine; consequently, a knowledge of its chemical and mechanical properties must be of decided importance to the practical engineer.

WATER AND ITS ELEMENTS.

Water, or oxide of hydrogen, is a slightly compressible fluid, composed of two gaseous or elementary bodies, which unite in the following proportions, water being the result of their union :—

	WEIGHT.	BULK.
Oxygen	8	1
Hydrogen	1	2
Equivalents	9	3

Or one cubic inch consists of

	GRAINS.	CUBIC INCHES.
Oxygen	224.46	662
Hydrogen	28.06	1325
	252.52	1987

Water, when pure, is transparent, colourless, tasteless, inodorous, and not liable to spontaneous change; liquid at the common temperature of our atmosphere; assuming a solid form at 32° Faht., and a gaseous state at 212°, but returning unaltered to its liquid state on resuming any degree of heat between these points; dissolves numerous vegetable, animal, and mineral substances; is decomposed in many cases of chemical action, affording oxygen or hydrogen to the substances which affect it.

Clean iron and zinc at a red heat possess the property of decomposing water when in the state of highly-rarefied steam;—the oxygen uniting with the metal, a solid metallic crust is formed on the surface, and the hydrogen set at liberty; one volume of oxygen, or from five to six of atmospheric air, combined with two of hydrogen,

render the mixture inflammable, and on the approach of a flame, red-hot iron, or the electric spark, the whole is kindled at the same instant, a flash of light passes through the mixture, followed by a violent explosion, the result of which is steam at 212° Faht., and ultimately pure water.

But water, as it exists in nature, contains various saline or earthy matters, as muriate of soda, or common salt, sulphate of lime, carbonate of lime, muriate of magnesia, oxide of iron, &c., which it accumulates in flowing through the different strata of rocks and minerals, constituting mineral or hard water, by which it is considerably reduced in value for the purposes of a steam-engine. Rain and snow waters are the purest natural waters we possess, and are generally employed as the standard of comparison for the densities of other bodies.

Specific gravity of pure rain water = 1, or one cubic foot at a mean temperature of the atmosphere = 1000 ounces.

Ten pounds of rain or distilled water, at 62° Faht., equal the standard gallon, or measure of capacity. And one cubic inch, at 62° Faht. = 252.458 grains.

Mineral waters of every description are more or less injurious to a boiler; and, unless very frequently changed, become in a state of saturated solution, in consequence of which earthy matters are deposited, and an incrustation formed on the surface of the iron, preventing the free passage of caloric; hence, the plates get red hot, and render the boiler in danger of being destroyed.

Mineral waters are generally divided into four classes, namely, the *acidulous*, the *sulphureous*, *chalybeate*, and *saline*.

Acidulous waters contain carbonic acid in its free state, or in combination in excess with a base; also, very frequently muriate of soda, and some of the earthy carbonates; however, it is the free carbonic acid that

imparts to them their particular properties. These waters are easily distinguished by their slightly acid taste, and sparkling appearance when poured from one vessel to another, both of which properties they lose by boiling, or standing exposed to the air for any short length of time.

Sulphureous waters contain sulphureted hydrogen, also alkaline, earthy sulphates, and muriates; they are very readily distinguished by their odour, and by causing a piece of silver, when immersed in them, to acquire a dark colour.

Chalybeate waters are those which have iron as an ingredient; they are known by their peculiar taste, and by their becoming black when mixed with an infusion of nutgalls; but they are of different kinds; sometimes the iron is combined with sulphuric acid,—more frequently it is in union with carbonic acid.

Saline waters are those which contain the saline ingredients generally found in mineral waters, but which have not carbonic acid in excess, and are free from sulphureted hydrogen and iron, or contain them in very trifling quantities. Saline waters may be subdivided into four kinds, namely—alkaline waters, or those which contain alkali in its free state, or combined with carbonic acid, and which render the vegetable blues green; hard waters, or those which combine carbonate or sulphate of lime; salt waters, or those in which muriate of soda abounds; purgative waters, or those which contain principally sulphate of magnesia.

To acquire at once a general knowledge of the properties of any water, the following experiments may be tried:

1. Evaporate a drop on a flat slip of glass, holding it before the fire, or above a small lamp or candle. Small rings only appear where the water rested, if it contained only a minute quantity of foreign matter; but a crust is seen if it be loaded with saline or earthy matter, and *the crust has* an ochry tint if iron be present.

2. Pour some of the water into a wine glass, and add a solution of litmus; it will be reddened if any acid matter be present.

3. Mix another portion with a little soap; a curdy matter appears if it abound with earthy matter.

Sea water contains of saline and earthy matter in every 100 parts,

Common salt	2.66
Sulphate of soda	.466
Muriate of lime	.199
Muriate of magnesia	.991
	4.316 parts of

saline and earthy matter. Average specific gravity 1028. Hence the necessity of frequently renewing the water in marine engine boilers at sea, by the usual process of *blowing out;* that is, by a little extra feed the boilers are allowed to fill, say, from four to six inches above the regular height, and the overcharged water blown out by the force of the steam, through a cock in the bottom of the boiler, about once every two hours.

I may here be allowed to observe, that Hall's Patent Condensers must be of considerable benefit to marine boilers on long voyages, not only from the saving of the boilers, but from the saving of fuel, if the distilling apparatus can be kept in proper condition, so as to supply sufficiently the unavoidable waste, and the tubes in the condenser kept tight, so as to prevent the sea water mingling with the condensed vapour, for fresh water boils at 212° Faht., and water saturated with salt at 224°.

MECHANICAL PROPERTIES OF WATER.

1. Fluid bodies in general exert an equal force or pressure in every direction, namely, upwards, downwards, sideways, and oblique, and fluids always tend to a level; hence, any quantity of water, however small, may be made to balance and support any quantity, however large.

2. The weight of water, or any other fluid body, is as the quantity; but the pressure is as the perpendicular height.

3. The pressure on the sides of any vessel containing a fluid is equal to the length of the side multiplied by half the square of the depth.

4. The centre of pressure, and also the centre of percussion, in a fluid, is two-thirds of the depth from the surface.

5. The quantity of water discharged through an orifice in equal times, but under different heads, is nearly as the corresponding heights of the different heads of water; hence,

$$\frac{\text{The square root of the depth in feet} \times \text{by the falling surface in inches}}{\text{Area of the orifice} \times 3.7} =$$

the time required in seconds.

Maximum density of water 42° Faht.
Freezing point 32° Faht., at which point it has expanded $\frac{1}{17}$ of its original bulk.

62.5 lbs. avoirdupois = the weight of 1 cubic foot.
.03617..... = ...1 " inch.
.434..... = ...1 lineal ft. 1 in. sq.
49.1..... = ...1 cylindrical foot.
.02842..... = ...1 " inch.
.341..... = ...1 lin. ft. 1 in. dia.
11.2 imperial galls. = ...1 cwt.
224. ..... = ...1 ton.
1.8 cubic feet.... = ...1 cwt.
35.84 ..... = ...1 ton.
1 cubic foot of water = $6\frac{1}{4}$ imperial gallons, and
1 cylindrical foot = about 5.

The content of any vessel in cubic feet × by 6.232
Or " " inches × by .003607 } = imperial gallons.

$$\frac{\text{Any number of imperial gallons}}{\text{Any two dimensions of a cistern in feet} \times \text{by } 6.232} = \text{the third dimension in feet.}$$

$$\frac{\text{Any number of imperial gallons}}{\text{Any two dimensions of a cistern in inches} \times \text{by } .003607} = \text{the third dimension in inches.}$$

The length of a cylinder in feet × by the square of the diameter in feet, and by 4.895..
The length of a cylinder in feet × by the square of the diameter in inches and by .034
The length of a cylinder in inches × by the sqr. of the diameter in inches and by .002832
} = Imp. gallons.

$$\sqrt{\frac{\text{any number of gallons a cylinder is required to contain} \times \text{by } 354}{\text{by the length in inches}}} = \text{the diameter of the cylinder in inches.}$$

$$\frac{\text{Any number of gallons a cylinder is required to contain} \times \text{by } 354}{\text{by the square of the diameter in inches}} = \text{the length of the cylinder in inches.}$$

The cube of the diameter of a sphere in inches × by .001888 = imperial gallons.

The velocity of water in feet per minute × by the square of a pump's diameter in inches, and by .034 = imperial gallons discharged per minute.

The velocity of water in feet per minute × by the square of a pump's diameter in inches, and by .0005454 = cubic feet discharged per minute.

STEAM.

Steam, or water in the state of vapour, is an elastic gaseous body, composed of water combined with caloric, or the matter of heat; transparent and colourness until it comes in contact with the atmosphere, it then assumes a dense white mass, and ultimately pure water.

Steam ascends from water at 212° Faht. equal to 14.7 lbs. avoirdupois per square inch, or the pressure of the atmosphere, generally termed one atmosphere, one cubic inch of water producing about one cubic foot of steam; but any additional pressure requires an elevation of temperature, and an increase of water, as in the following table :—

Atmospheres.	Lbs. per square inch above the Atmosphere.	Temperature in degrees of Faht.	Volume of Steam, Water being 1.	Cubic Inches of Water in a Cubic Foot of Steam.	Elastic Force in Inches of Mercury.	Elastic Force in Feet of Water.
1.19	2.5	220F	1496	1.14	5.15	5.76
1.22	3	222	1453	1.18	6.18	6.91
1.29	4	225	1366	1.25	8.24	9.22
1.36	5	228	1282	1.33	10.3	11.52
1.70	10	240	1044	1.64	20.6	23.05
2.04	15	251	883	1.93	30.9	34.57
2.38	20	260	767	2.23	41.2	46.10
2.72	25	268	678	2.52	51.5	57.62
3.06	30	275	609	2.81	61.8	69.15
3.40	35	282	553	3.09	72.1	80.67
3.74	40	288	506	3.38	82.4	92.20
4.08	45	294	468	3.66	92.7	103.72
4.42	50	299	435	3.93	103.0	115.25
4.76	55	304	407	4.20	113.3	126.77
5.10	60	309	382	4.48	123.6	138.30

NOTE.—An atmosphere is equal to 30 inches, or .762 metres of mercury, it is also equal to 14.7 lbs. avoirdupous per square inch, or 11.55 lbs. per circular inch.

Steam is produced from water at 212° Faht. as before observed, equal to the pressure of the atmosphere, or about 14.7 lbs. avoirdupois per square inch, and,

under such circumstances, cannot attain either a greater force or a higher temperature; but let the water be inclosed from atmospheric pressure, and the boiler made so tight that steam cannot escape, the fire being still continued, the water will imbibe caloric until the steam becomes so strong as to tear the boiler to pieces.

TO FIND THE PROPER DIAMETER FOR A SAFETY VALVE.

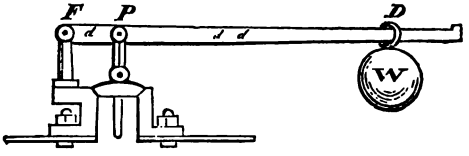
RULE.—Multiply the bottom surface of the boiler, or surface immediately exposed to the action of the fire, in feet, by the multiplier opposite to the pressure in lbs. on each square inch of the safety valve, and the square root of the product is the valve's diameter in inches at the narrowest part. If the boiler is to have two safety valves, then the square root of half the product equals the diameter of each.

Pressure in lbs. per square inch.	Multipliers.	Pressure in lbs. per square inch.	Multipliers.
3	.356	15	.315
4	.353	20	.305
5	.348	25	.293
6	.344	30	.289
7	.339	35	.282
8	.336	40	.275
10	.329	45	.270
12	.321	50	.264

The diameter of a valve in inches, multiplied by the diameter in inches, equal the superficial content, or area of the valve, in circular inches, or what is termed *the square of the diameter;* and the square of the diameter multiplied by .7854 equal the superficial content in square inches, consequently the weight in lbs. on the safety valve, divided by the area in square or circular inches, equal the pressure in lbs. on each square or circular inch of the boiler.

When there is no lever attached to a valve, the weight divided by the area equal the direct pressure; but when a lever is applied, the principle of the lever must be

taken into account, and may be estimated thus :—Ascertain the weight of the valve, and also the action of the lever upon the valve; the action is found sufficiently near by dividing the whole length of the lever by the distance between the fulcrum and the valve, and multiplying the quotient by half its weight.



In the above section of a valve with a lever, let F denote the fulcrum, P the whole pressure upon the valve, D the distance of the weight from F, d the distance between F and P, $d\,d$ the distance between F and D, W the weight upon the lever, and p the action of the lever upon the valve.

Then 1. $\frac{\overline{P - p} \times d}{d\,d} = W.$ 2. $\frac{\overline{P - p} \times d}{W} = D.$

3. $\frac{W \times d\,d}{d} + p = P.$

Example.—Suppose 95 lbs. to be the whole weight or pressure required upon a valve, and the,

Weight of the valve .... = 2 lbs.
Weight of the lever .... = 3 „
Distance between F and P = 3 inches.
Distance between P and D = 18 „

To find W, or the weight required upon the lever.

$\frac{18\ inches}{3\ inches} \times 1.5$ lbs. + 2 lbs. = 11 lbs. or the action of the lever and weight of the valve.

Hence, $\frac{\overline{95 - 11} \times 3}{18} = 14$ lbs. or W.

$\frac{\overline{95 - 11} \times 3}{14} = 18$ inches, or $d\,d$.

$\frac{14 \times 18}{3} + 11 = 95$ lbs. or P, the pressure upon the valve.

When greater accuracy is required, counterpoise the lever by weights at F, making P the centre of motion; hence, the weights at F, plus the weight of the lever, is the real action upon the valve. And the rules are the same throughout, whether a weight or spring balance be applied, observing to take the weight of the spring balance into account.

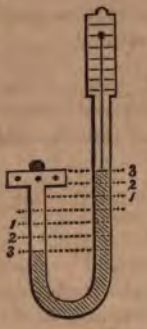
When a spring balance is applied to the lever of a safety valve, the distance between F and P = the diameter of the valve in inches, and the distance between F and the spring balance, or the end of the lever = as many times the diameter of the valve as there are square inches in its area.

THE STEAM GAUGE

Is an indicator of constant reference in ascertaining the elastic force or pressure of the steam in a boiler, and which is very important to be known, for, according to the state of the fire, the steam may get so low as to allow a vacuum to be formed in the boiler, or it might be considerably too high, although escaping partly by the safety valve; hence, the steam gauge is a general test for regulating the fire; or if by any means the valve get fastened, and the steam still accumulating, the mercury will be driven out of the tube, and then become partially a safety valve.

The common construction of a steam gauge is an inverted syphon, or bent tube of wrought iron, containing a sufficiency of mercury to resist the required pres-

sure of steam in the boiler, one end being fixed to the boiler, and the other open to the atmosphere; but the action of the column of mercury will appear more plain by means of the following section;—



Each inch of a rise indicates a pressure of 1 lb.

Level of the mercury when there is no pressure of steam.

The steam depresses the mercury in the short tube, consequently causes it to rise in the longer one; 2 inches of mercury is a counterpoise to 1 lb. pressure of steam, therefore a rise of 1 inch in the long tube indicates a force equal to 1 lb. per square inch in the boiler.

A FLOAT

Is as requisite for ascertaining the height of the water in a boiler as a gauge is for the height of the steam, but can only be properly applied in a land or fixed engine boiler, and may consist of either *stone*, *iron*, *copper*, or any other body that will not be destroyed by the heat of the water or force of the steam; hence, a float may be made so heavy as to sink in the water, consequently a counterpoise is required; or it may be made so buoyant that it will neither be steady in the boiler, sink to the depth required, nor will it fall by

its own gravity when the water is getting low, therefore additional weight must be attached, and in either case the float immersed about $\frac{2}{3}$ds of its thickness or depth.

RULE 1.—*When too heavy*, subtract the weight of the water displaced from the weight of the float; the remainder is the counterpoise required.

RULE 2.—*When too buoyant*, subtract the weight of the float from the weight of the water displaced; and the remainder is the weight that must be added to the float.

NOTE.—The weight must either be inside the float, or otherwise attached, clear of the surface of the water.

EXAMPLE 1.—Required the weight necessary to counterpoise a float of paving stone, 14 inches diameter, $2\frac{1}{4}$ inches thick, and immersed two-thirds of its thickness in fresh water;

say, the weight of stone and rod attached $= 30\frac{1}{2}$ lbs.

then, $\frac{14^2 \times .7854 \times 2.25 \times 2}{3} = 230.9$ inches of water displaced.

1 inch of water $= .03617$ lbs. avoirdupois; hence,
$230.9 \times .03617 = 8.35$ lbs. of water displaced, and
$30.5 - 8.35 = 22.15$ lbs. required for a counterpoise.

EXAMPLE 2.—Suppose a float to consist of a concave copper ball, 12 inches diameter outside, and weigh with rod attached $7\frac{1}{4}$ lbs.; required the weight that must be added inside, so that the ball may remain immersed half its depth in fresh water.

$\frac{12^3 \times .5236 \times .03617}{2} = 16.36$ lbs. of water displaced,

and $16.36 - 7.25 = 9.11$ lbs. that must be added to the float.

GAUGE COCKS AND GLASS TUBES

Are intended to show the height of water in a boiler where a float cannot properly be applied, as in *marine and locomotive engines;* they are also becoming common in *land* boilers, and are very necessary appendages, but require particularly strict attention under the following circumstances;—namely, *all new boilers, boilers immediately after being cleaned, and marine boilers in passing from fresh to salt water, or from salt to fresh, more especially water holding earthy and other matters in solution;* but in either case the water becomes frequently in a state of complete fermentation, the boiler appears to contain more than a sufficient quantity of water, when in reality there may not be *solid* water, as it is termed, at the first cock, which ought not to be less than from three to four inches above the top of the highest flue. Putting a few pounds of tallow in a marine boiler, previous to getting up steam, or firing light, when fermentation, or *priming*, as it is frequently called, is likely to occur, are the usual modes of prevention; but the same applied to locomotive boilers, in many instances increase the fermentation in place of lessening it, and nothing but a boiler free from any earthy substance will thoroughly prevent it, which must be obtained by *blowing out*, and thoroughly changing the water.

It may not be amiss here to impress upon the mind the very great necessity of a constant sufficiency of water in the boiler, for a volume of steam suddenly formed is attended with considerably *greater danger* than an excess of steam regularly accumulated, as the safety valve will allow part to escape during its formation, and also give warning of its progression, but the valve cannot act so instantly and efficiently as is required if steam be suddenly generated, which, I have no doubt, is the case where some of the plates of a boiler are red hot when the engine is started, and if not the cause of an *explosion*, may be the means of materially *injuring the boiler.*

THE FEED PIPE AND FEED PUMP.

Boilers are supplied with water in two ways, namely, by the gravity of the water alone, and by means of a force pump applied to the engine.

When a boiler is supplied by the gravity of the water, the pipe attached to the top of the boiler, containing the column of water, is designated the feed pipe, the one from the pump being only for the purpose of conveying the water to the top of the feed pipe, the height of which requires to be at least $2\frac{1}{2}$ feet above the surface of the water in the boiler for every pound pressure on a square inch of the safety valve.

To ascertain the capacity of the feed pump.

If the exact consumption and waste of steam, imperfections of the pump, leakages of the boiler, &c., could be properly ascertained, the pump's capacity could easily be determined, but this being impossible, its dimensions can only be regulated by being made sufficiently large not only to keep up the quantity of water which is constantly required, but also to be enabled to meet the greatest contingencies in all ordinary cases of the engines working: hence observe the following

RULE.—Multiply the area of the piston in feet by its velocity also in feet per minute, and by three times the quantity of water in a cubic foot of steam, at the required pressure in lbs. per square inch;—divide the product by the length of the pump's stroke in inches multiplied by the number per minute, and the quotient is the pump's area in inches; or, divide the product by its area, multiplied by the number of strokes per minute, and the quotient is the length of stroke.

EXAMPLE 1.—Required the diameter of feed pump for an engine whose cylinder is 2 feet diameter, length of stroke 4 feet, and making 27 revolutions per minute, or the velocity of the piston equal 216 feet, the pressure

of steam equal 4 lbs. per square inch, and the length of the pump's stroke equal 18 inches.

The quantity of water in a cubic foot of steam at 4 lbs. per square inch equal 1.25 cubic inches, *(see page* 20,*)* and $1.25 \times 3 = 3.75$.

And the area of a cylinder 2 feet diameter $= 3.14$ *(see Table* 10.*)*

Also, $18 \times 27 = 486$. Hence $\frac{3.14 \times 216 \times 3.75}{486}$

$= 5.23$ inches area, or nearly 2.6 inches diam.

2.—Suppose the engine as above described, and existing under similar circumstances of velocity, pressure, &c., but the area of the pump given 5.23 inches, required the length of stroke.

$5.23 \times 27 = 141.21$. And $\frac{3.14 \times 216 \times 3.75}{141.21}$

$= 18$ inches length of stroke.

NOTE.—The suction and delivering pipes to any pump ought not to be less than two-thirds of the pump's diameter; and in the delivering pipe to the boiler, in high-pressure engines, particularly locomotives, a small *cock* should be inserted, so as to allow the steam and air which accumulates in the pipes to escape, otherwise the boiler is frequently prevented from being regularly supplied.

THE BOILER.

The *boiler* is a vessel of either *wrought iron*, *cast iron*, or *copper*, and contains water to which heat is applied, and steam generated. Boilers are not confined to any one particular form, having for their general principle *strength, compactness, and durability*, and containing the greatest superficial heating surface under the least cubical content; hence, their forms are so exceedingly various that any attempt here to introduce either plans or specifications would be quite inconsistent with the design of this work, and of comparatively little value in point of daily reference; but, there are several rules and proportions, deduced from experiment and practice, that are of particular advantage, and ought to be attended to.

1.—*Boilers to which coal is applied in the usual form.*

In such boilers it is ascertained that about 500 square feet of effective heating surface, having about 60 square or superficial feet of fire properly applied, will evaporate one cubic foot of water per minute; hence, when the quantity of steam required is known, the quantity of heating surface and extent of fire-grate is easily obtained, and this depends considerably upon the *eccentric and slide valve.*

From the nature of an eccentric, although a valve has neither lap nor lead, the steam admitted into the cylinder is only about $\frac{3}{4}$ths the capacity of the cylinder, consequently $\frac{3}{4}$ths the piston's velocity, and when the steam is sooner cut off, as it generally is, an additional saving is obtained, but on account of the waste of steam in the apertures, imperfections, &c., it is not prudent to calculate a boiler for less. Hence to determine the effective heating surface in a boiler,

Let A denote the area of the cylinder in feet.
P .... $\frac{3}{4}$ths of the piston's velocity in feet per min.
500 .... the effective heating surface to evaporate 1 cubic foot of water per minute.
V .... the volume of steam from 1 of water.
And S .... the effective heating surface required in square feet.

$$\text{Then,} \frac{\text{A P } 500}{\text{V}} = \text{S.}$$

Or, in other words, Multiply the area of the piston in feet by $\frac{3}{4}$ths of its velocity in feet per minute, and by 500; divide the product by the volume of steam from 1 of water, and the quotient is the effective heating surface in square feet.

Example.—Required the heating surface of a boiler for an engine with a cylinder of 2 feet diameter; velo-

city of piston 220 feet per minute, and pressure of steam 4 lbs. per square inch.

$\frac{3}{4}$ths of 220 = 165, and the volume of steam from 1 of water, at 4lbs. per square inch = 1366 *(see Table, page 20.)*

Hence, $\frac{3.14 \times 165 \times 500}{1366} = 189.6$ square feet.

The fire surface or area of furnace bars equal 60 divided by 500 or .12 of a square foot to every foot of effective heating surface, consequently, in this case, 189.6 × .12 or 22.75 = the square feet of fire, or furnace bars.

The proportions for waggon-shaped boilers are as follow :—

Half the effective heating surface = the bottom surface.

Twice the square root of the bottom surface in feet = the length.

Half the square root in feet = the width. And

One-third the length = the height.

NOTE.—All horizontal surfaces over fire, flame, or heated air, are effective ; but vertical or side surfaces require about 1.75 feet to be equally effective to one of horizontal surface.

EXAMPLE.—Let the effective heating surface of a boiler = 120 feet ; then 60 = the bottom surface, and

$\sqrt{60} \times 2 = 15.48$ feet, the length.
$\sqrt{60} \div 2 = 3.87$,, width.
$15.48 \div 3 = 5.16$,, height. About twice the length and width of the boiler = the length of the flue, And $60 \times 1.75 = 105$ feet of side surface, then $15.48 \times 2 + 3.87 = 34.8$; hence $\frac{105}{34.8} = 3$ feet, the depth of the side surface.

Again,—In cylindrical boilers $\frac{1}{3}$rd must be added to the effective heating surface, so as to make the curve

surface = to horizontal surface; hence, suppose 60 feet = the effective surface,

$\sqrt{60 + 20} = 8.94$ feet, or half the circumference of the boiler,

And $8.94 \times 2 = 17.88$ feet the length.

Boilers are frequently made with internal flues, with a view to increase the quantity of heating surface, and reduce the cubical capacity of the boiler: when such is the case, let the effective heating surface gained be taken from the length of the boiler, and not from the width, as the heat will be sufficiently given out by the extra length of flue inserted.

The depth, or body of water contained in a boiler, ought to be about $\frac{2}{3}$rds of the whole height of the boiler, for when there is a considerable body of water in a boiler the steam is less liable to fluctuation.

2.—*Boilers for locomotives where coke is used, and a blast pipe applied.*

In boilers of this description the evaporating power depends, in a great measure, upon certain proportions existing between the *tubes, the chimney, and the orifice of the blast pipe.*

The blast pipe in a locomotive is a copper or other metal tube, for the purpose of conducting the steam from the cylinders to the bottom of the chimney, so that it may there be emitted at a certain velocity, to expel the air in the chimney, and cause a current of heated air to pass from the fire through the tubes at each half stroke of the engines; consequently, the more the heated air is diffused in the boiler by a number of tubes or pipes, the less is the current required to be, and the larger the orifice of the blast pipe, for the following reason:—*A tube twice the diameter contains only twice the circumference or heating surface, but four times the area;* hence, in large tubes the velocity must be con-

siderably increased, so as to compensate for the loss of heated air passing through the body of the tube. But,

Although a greater quantity of tubes would diffuse a greater quantity of heat through the water, other circumstances interfere, as the quality of the coke, &c., therefore practice has dictated a certain size as the most beneficial to be used, and I believe it is generally found that brass tubes, from $1\frac{5}{4}$ to 2 inches diameter outside, and about No. 13 wire gauge, are the most advantageous.

Again, the diameter of the *chimney* materially affects the blast pipe, for the wider the chimney the greater is the column of air to displace,—hence, the smaller the orifice of the blast pipe; but, indeed, they are so linked together that nothing but several trials with the engine can decide the exact proportions, so that the one part may accommodate the other.

However, in practice we find that a boiler, containing about 90 two-inch tubes, having a 12-inch chimney, and a $2\frac{5}{4}$-inch *blast pipe*, will generate a sufficiency of steam, from 50 to 60 lbs. per square inch above the pressure of the atmosphere, to supply two cylinders 12 inches diameter each.

NOTE.—The chimney is generally the same diameter as the cylinder, and about 6 feet long.

It is also ascertained from practice, that about three square feet of heating surface in the fire-box, or nine square feet in the tubes, will evaporate one cubic foot of water per hour in a boiler as already described, and kept under like circumstances, from which we deduce the following rule:—

Let V = the velocity of the engine in feet per hour,
l = length of the stroke in feet,
p = area of the piston in feet,
3 = effective evaporating surface in the boiler to each cubic foot of water,
d = diameter of the wheels in feet,
r = ratio, or volume of steam from one of water.

And S = the effective generating surface of the boiler in square feet;

$$\text{Then } \frac{V\ l\ p\ 3}{r\ d} = S.$$

Or, in other words, Multiply the velocity of the engine in feet per hour by the length of the stroke, and by the area of the piston also in feet, also by 3, or the effective evaporating surface of the boiler, and divide the product by the diameter of the wheels in feet multiplied by the ratio or volume of steam from one of water, and the quotient is the effective generating surface of the boiler in square feet.

EXAMPLE.—Suppose a locomotive with two cylinders of 11 inches, or .917 feet diameter each, stroke 1.33 feet, wheels 5 feet diameter, velocity 20 miles per hour, force of steam 50 lbs. above the pressure of the atmosphere; required the effective heating surface in the boiler.

$.917^2 \times .7854 = .66$ feet, area of the piston.
$5280 \times 20 = 105600$ feet, velocity of the engine per hour.
435 = the volume of steam to one of water—*(see Table, page 20.)*

$$\text{Hence } \frac{105600 \times 1.33 \times .66 \times 3}{435 \times 5} = 128 \text{ square feet,}$$

And $\frac{1}{3}$ of 128 = 43 square feet in the fire-box.

The tube surface, or communicative heat, requires to be multiplied by 3, as before stated, to equal the surface in the fire-box, or radiating caloric; therefore $128 - 43 = 85 \times 3 = 255$ square feet of surface in the tubes.

And, Suppose the tubes 7 feet in length, $\frac{255}{7} = 36.43$ feet for the whole circumference of the tubes.

Again, Suppose each tube $1\frac{3}{4}$ inches inside, or nearly 5.5 circumference,

$$\frac{36.43 \times 12}{5.5} = 80 \text{ tubes contained in the boiler.}$$

A Table of the weight of a superficial foot of various metals in lbs. avoirdupois.

NAMES.	THICKNESS IN PARTS OF AN INCH.											
	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{3}{4}$	$\frac{7}{8}$	1 in.
Iron in lbs ...	2.5	5	7.5	10	12.5	15	17.5	20	25	30	35	40
Copper in lbs	2.9	5.8	8.7	11.6	14.5	17.4	20.3	23.2	28.9	34.7	40.4	46.2
Brass in lbs...	2.7	5.5	8.2	10.9	13.6	16.3	19	21.8	27.1	32.5	37.9	43.3
Lead in lbs...	3.7	7.4	11.1	14.8	18.5	22.2	25.9	29.6	37	44.4	57.8	59.2

NAMES.	THICKNESS BY THE BIRMINGHAM WIRE GAUGE.									
	1	2	3	4	5	6	7	8	9	10
Iron in lbs ...	12.5	12	11	10	8.74	8.12	7.5	6.86	6.24	5.62
Copper in lbs	14.5	13.9	12.75	11.6	10.1	9.4	8.7	7.9	7.2	6.5
Brass in lbs...	13.75	13.2	12.1	11	9.61	8.93	8.25	7.54	6.86	6.18

NAMES.	THICKNESS BY THE WIRE GAUGE.									
	11	12	13	14	15	16	17	18	19	20
Iron in lbs ...	5	4.38	3.75	3.12	2.82	2.5	2.18	1.86	1.7	1.54
Copper in lbs	5.8	5.08	4.34	3.6	3.27	2.9	2.52	2.15	1.97	1.78
Brass in lbs...	5.5	4.81	4.12	3.43	3.1	2.75	2.4	2.04	1.87	1.69

NAMES.	THICKNESS BY THE WIRE GAUGE.									
	21	22	23	24	25	26	27	28	29	30
Iron in lbs ...	1.4	1.25	1.12	1	.9	.8	.72	.64	.56	.5
Copper in lbs	1.62	1.45	1.3	1.16	1.04	.927	.835	.74	.649	.58
Brass in lbs...	1.54	1.37	1.23	1.1	.99	.88	.79	.7	.616	.55

PROPERTIES OF VARIOUS METALS.

Welding heat of iron 12780° Ft.....1 foot in length contracts in cooling .137 of an inch.
Power of conducting heat to another body 37.41.
Copper melts at 4587° Ft.....contracts in cooling .193
Conducting heat.....89.82.
Brass melts at 3807° Ft.....contracts in cooling .210
Conducting heat about the same as copper.
Lead melts at 594° Ft.....contracts in cooling .319
Conducting heat.....17.96.
Tin melts at 442° Ft.....contracts in cooling .278
Conducting heat.....30.38.
Water expands in heating from 32° to 212°, about 0.0434 of its bulk.

THE STEAM-ENGINE.

Steam-engine is a general term of application to all machines where steam is made available as a motive power; hence, the various familiar names—condensing engines; non-condensing or high pressure engines; reciprocating engines; rotatory engines; land engines; marine engines; locomotive engines, &c.,—in each of which the principle of motion is the same, but distinguished by some appellation of prominent feature, or application to which it is most particularly suited.

But the greater portion of engines consists of alternate rectilinear or reciprocating motion communicated to a crank, whereby a continued circular motion is obtained and rendered uniform by a fly-wheel, or otherwise,—as, when employed in propelling vessels, the motion is transferred to the vessel itself by the resistance of the paddles in the water, the velocity of which causes a similar uniformity in the engine; and the same takes place in a locomotive, by the adhesion of the wheels to the rails; hence, the alternate motion of the piston governs

the velocity of the engine, and is not at all confined, for the greater the force the greater the velocity, and the greater the velocity the greater the power, providing there be a constant sufficiency of steam to continue the motion, and overcome the resistance to which the engine is applied. But,

There is a maximum velocity for an engine, or that velocity whereby the greatest effect is produced from the pressure of steam applied; and, to ascertain this point, the uniform force of the steam throughout the stroke must first be obtained by the following rule :—

Divide the length of the stroke in inches by the distance the piston has moved before the steam is cut off, and divide the whole pressure on a square inch of the piston in lbs. by the quotient. Add 1 to the hyperbolic logarithm of the number of times the steam is expanded, and multiply the logarithm by the number of lbs. to which the steam is expanded, and the product is the uniform force of the steam.

Table of Hyperbolic Logarithms.

No.	Log.	No.	Log.	No.	Log.	No.	Log.
1¼	.2231435	5⅞	1.7491998	15	2.7080502	33	3.4965075
1½	.4054651	6	1.7917594	16	2.7725887	34	3.5263605
1⅞	.5596157	6¼	1.8325814	17	2.8332133	35	3.5553480
2	.6931472	6½	1.8718021	18	2.8903717	36	3.5835189
2¼	.8109302	6¾	1.9095425	19	2.9444389	37	3.6109179
2½	.9162907	7	1.9459101	20	2.9957322	38	3.6375861
2¾	1.0116008	7¼	1.9810014	21	3.0445224	39	3.6635616
3	1.0986123	7½	2.0149030	22	3.0910424	40	3.6888794
3¼	1.1186549	7¾	2.0476928	23	3.2354942	41	3.7135720
3½	1.2527629	8	2.0794415	24	3.1780538	42	3.7376696
3¾	1.3217558	8½	2.1400661	25	3.2188758	43	3.7612001
4	1.3862943	9	2.1972245	26	3.2580965	44	3.7841896
4¼	1.4469189	9½	2.2512917	27	3.2958368	45	3.8066624
4½	1.5040774	10	2.3025851	28	3.3322045	46	3.8286414
4¾	1.5581446	11	2.3978952	29	3.3672958	47	3.8501476
5	1.6094379	12	2.4849066	30	3.4011973	48	3.8712010
5¼	1.6582280	13	2.5649493	31	3.4339872	49	3.8918203
5½	1.7047481	14	2.6390573	32	3.4657359	50	3.9120230

The following Table of Velocities is the result of practice and observation :—

Land Engines.			High Pressure Engines.			Marine Engines.		
Length of stroke in ft. & in.	Numb. per minute	Velocity in feet per minute.	Length of stroke in ft. & in.	Numb. per minute	Velocity in feet per minute.	Length of stroke in ft. & in.	Numb. per minute	Velocity in feet per minute.
1 6	50	150	1 0	80	160	2 0	42	168
2 0	43	172	1 6	62	186	2 3	39½	177¾
2 6	38	190	2 0	50	200	2 6	36	180
3 0	34	204	2 6	42½	212½	2 9	33	181
3 6	30	210	2 9	39½	217¼	3 0	31	186
4 0	27	216	3 0	37	222	3 6	27	189
4 6	24¼	218¼	3 6	33	231	4 0	24	192
5 0	22	220	4 0	29½	236	4 6	21½	193½
5 6	20¼	224¾	4 6	27	243	5 0	20	200
6 0	19	228	5 0	24¾	247½	5 6	19	209
7 0	17½	245	5 6	23	253	6 0	18	216
8 0	16	256	6 0	22	264	7 0	15¾	220½

These are to be considered as the velocities of engines having the application of their power in the usual form. Sometimes the motion is communicated by a lever or half beam, and having the power transmitted from somewhere between the fulcrum and the piston, or end of the lever, in which case the velocity of the engine must be increased in the following proportion :—

RULE.—Multiply the velocities in the table by the length of the lever in feet between fulcrum and piston, and divide the product by the distance between the fulcrum and connecting rod, the quotient is the velocity in feet per minute.

EXAMPLE.— Suppose a marine engine of this description with a 3 feet 6 in. stroke, length of lever 11 feet, and the connecting rod attached 2½ feet from the piston ; required the piston's velocity.

By the table, a 3 feet 6 stroke = 189 feet per minute,

$$\text{and } \frac{189 \times 11}{8.5} = 244.5 \text{ feet.}$$

In the velocities of marine engines, the vessels are supposed in their average sailing trim, in moderate weather, and the dimensions of the paddle boards determined according to the following approximate:—

RULE.—Multiply the area of the cylinder in inches by *nine times* the force of the steam in lbs. on a square inch of the boiler above the pressure of the atmosphere, divide the product by the diameter of the wheels in feet multiplied by the velocity of the piston in feet per minute, and the quotient is the area of each paddle board in square feet for vessels with two engines, and half the quotient for vessels with one engine only.

EXAMPLE.—Suppose a vessel containing two engines, with cylinders of 50 inches diameter each, stroke $4\frac{1}{2}$ feet, wheels 20 feet diameter, and steam at 4 lbs. per square inch above the pressure of the atmosphere; required the area of each paddle board in square feet.

$50^2 \times .7854 = 1963.5$ inches, area of cylinder; $9 \times 4 = 36$; and by the table a $4\frac{1}{2}$ feet stroke $= 193\frac{1}{2}$ feet velocity.

Hence, $\frac{1963.5 \times 36}{193.5 \times 20} = 18.2$ feet; and suppose each 8 feet in length, $18.2 \div 8 = 2.28$, or 2 feet 3 inches broad nearly.

NOTE.—In the preceding table of velocities the pressure of the steam for land engines is taken at an average of 3 lbs., high pressure engines 30 lbs., and marine engines 4 lbs. per square inch above the pressure of the atmosphere.

Velocity of locomotive engines.

In order to ascertain what load a locomotive engine is able to draw at a given velocity, or what velocity it will acquire with a given load, the following require to be taken into account, namely,—

The force of the steam; the pressure of the atmosphere; the dimensions of the cylinders; the diameter of the wheels; the weight of the load; the force of traction per ton; and the friction of the engine. It is already decided by experiment and practice, that about

9 lbs. per ton is the amount of the force of traction upon a level, when the line of rails and waggon axles are kept in proper condition, the bearings of the axles being from 4 to 4½ inches in length by 2½ in diameter, and wheels about 3 feet diameter; and also the amount of resistance and friction of the engine per ton equal about 15 lbs. (The quantity of water that a boiler will evaporate in a given time is given under the section on boilers, *see page* 31.) Hence, in both cases,

Let P denote the total pressure of steam in the boiler per square foot (atmospheric pressure included,)

r .... the ratio of the volume of steam, water being 1, or the volume of steam to the volume of water that produces it,

S .... the quantity of water evaporated per hour in cubic feet,

D .... the diameter of the wheels in feet,

9 lbs. the resistance of the load per ton,

W .... the gross weight of the load in tons, tender, water, &c. included,

15 lbs. the resistance and friction of the engine per ton.

2117 lbs. the atmospheric pressure per square foot,

d .... the diameter of the cylinders in feet, or parts of a foot.

l .... the length of the stroke also in feet,

And V .... the velocity in feet per hour. Then,

1. To ascertain the load that a given engine will draw with a fixed pressure and a determined velocity.

$$\frac{\overline{\mathrm{P}\,r\,\mathrm{S}\,\mathrm{D} - 2117\,d^2\,l\,\mathrm{V}}}{\mathrm{V}\,9\,\mathrm{D}} - \frac{15 \text{ per ton}}{9} = \mathrm{W}$$

2. To ascertain the velocity to which an engine will acquire with a fixed pressure and a determined load.

$$\frac{\mathrm{P}\,r\,\mathrm{S}\,\mathrm{D}}{(9\,\mathrm{W} + 15)\,\mathrm{D} + 2117\,d^2\,l} = \mathrm{V}$$

EXAMPLE.—Suppose an engine of the following dimensions, namely,

Diameter of cylinders 11 inches, or .917 feet.
Stroke of the piston 16 „ or 1.33 „
Diameter of wheels 5
Effective pressure 50 lbs. per square inch, or 65 lbs. atmospheric pressure included,
38.74 cubic feet of water evaporated per hour,
Weight of the engine 8 tons,
Load, gross weight, tender included, 100 tons;
Required the velocity in miles per hour.

144 × 65 = 9360 lbs. pressure of steam per square foot or P,
435 = the volume of steam to 1 of water,—*(see Table, page* 20.)
100 × 9 = 900 lbs. resistance of the load,
15 × 8 = 120 lbs. resistance and friction of the engine,
And 5280 feet = 1 mile. Then,

$$\frac{9360 \times 435 \times 38.74 \times 5}{900 + 120 \times 5 + 2117 \times .9172 \times 1.33} = 105612 \text{ ft.}$$

and $\frac{105612}{5280} = 20$ miles per hour.

Again, suppose the engine as before, but with a fixed velocity of 20 miles per hour; required the load it will take in gross tons, tender included.

$$\frac{9360 \times 435 \times 38.74 \times 5 = 2117 \times .917^2 \times 1.33 \times 105600}{105600 \times 9 \times 5} =$$

$$113.13 - \frac{120}{9} = 100 \text{ tons.}$$

A Table containing the Velocities of Engines, with their given loads.

DESCRIPTION OF THE ENGINE.	Load in gross tons, tender included.	Velocity on a level, in miles per hour, with an effective pressure of steam in the boiler at 50 lbs. 55 lbs. and 60 lbs. per square inch.		
	Tons.	50 lbs. Miles.	55 lbs. Miles.	60 lbs. Miles.
Engine with cylinders 11 in. diam. Stroke of the piston 16 in. Diameter of wheels 5 feet. Weight of the engine 9½ tons. Effective heating surface 140 square feet. Water evaporated per hour 42 cubic feet.	25	40.07	40.38	40.60
	50	31.34	31.58	31.76
	75	25.74	25.93	26.06
	100	21.83	22.00	22.12
	125	18.96	19.10	19.21
	150	16.75	16.88	16.97
	175	.....	15.12	15.21
	200	.....	.....	13.60
Engine with cylinders 12 in. diam. Stroke of the piston 16 in. Diameter of wheels 5 feet. Weight of the engine 11 tons. Effective heating surface 140 square feet. Water evaporated per hour 42 cubic feet.	25	34.45	34.71	34.91
	50	27.30	28.01	28.16
	75	23.29	23.47	23.60
	100	20.05	20.21	20.32
	125	17.60	17.73	17.83
	150	15.68	15.80	15.89
	175	14.14	14.25	14.33
	200	.....	12.98	13.05
	250	.....	.....	10.75
Engine with cylinders 13 in. diam. Stroke of the piston 16 in. Diameter of wheels 5 feet. Weight of the engine 12 tons. Effective heating surface 160 square feet. Water evaporated per hour 48 cubic feet.	50	29.03	29.25	29.42
	75	24.68	24.86	25.00
	100	21.46	21.62	21.74
	125	18.98	19.13	19.23
	150	17.02	17.15	17.24
	175	15.42	15.54	15.63
	200	14.10	14.21	14.29
	225	12.99	13.09	13.16
	250	.....	11.80	11.72
Engine with cylinders 12 in. diam, Stroke of the piston 18 in. Diameter of wheels 5 feet. Weight of the engine 12 tons. Effective heating surface 160 square feet. Water evaporated per hour 48 cubic feet.	50	26.16	26.36	26.51
	75	22.57	22.74	22.87
	100	19.85	20.00	20.11
	125	17.71	17.85	17.95
	150	15.99	16.11	16.20
	175	14.57	14.68	14.77
	200	13.39	13.49	13.56
	270	.....	.....	11.05

This table supposes the resistance of the air to be nothing more than what is created by the train or load; a fresh breeze makes a very considerable difference; for

in the first case the resistance is only about 17 or 18 lbs. on a waggon of moderate height; but, if the velocity of the wind be about 20 feet per second, the resistance is equal to .915 lbs. per square foot,—or otherwise, a surface of one square foot, cutting the air with a velocity of 20 feet per second, meets with a resistance of .915 lbs.; hence, a surface of 30 square feet must meet with a resistance of $.915 \times 30 = 27.45$, or nearly $27\frac{1}{2}$ lbs.

Any rise or inclined plane upon a railway materially diminishes the velocity, or lessens the quantity of load an engine can take upon a level, on account of the resistance upon the plane approaching to the total weight of the load, for, according to the laws of inclined planes, the resistance or weight increases as the perpendicular height of the plane is to its length; hence, divide the weight of the load in lbs., including engine and tender, by any portion or length of the plane multiplied by 8, or the traction of the load per ton minus the friction of the engine, and the quotient, plus the weight of the load in tons, multiplied by 8, equal the total resistance of the load in lbs. upon the plane.

EXAMPLE.—Suppose a train or load of 100 tons, engine, tender, &c. 12 tons, which, upon a level, offers a resistance of $112 \times 8 = 896$ lbs.; required the increase of resistance upon an incline of 1 in 135.

$$2240 \text{ lbs.} = 1 \text{ ton; and } \frac{2240 \times \overline{100 + 12}}{135 \times 8} = 232 + 100 = 332 \text{ tons, } \times 8 = 2656 \text{ lbs.}$$

And the velocity acquired by a carriage or train descending a plane, although inversely, increases in an equal ratio; *hence, the necessity for individuals intrusted with the care or management of locomotive engines being particularly acquainted with the various effects of a train or load upon an incline, as well for their own as public safety, so that, by a competent knowledge, and proper attention, the engine may be regulated to a constant or uniform velocity, whereby general safety in a great measure is secured,*

Table containing the Resistance of Trains upon inclined planes.

Weight of the Engines.	Weight of the train in gross tons, tender included.	Load in gross tons, which on a level would offer the same resistance, the inclination of the plane being						
		$\frac{1}{300}$	$\frac{1}{400}$	$\frac{1}{300}$	$\frac{1}{250}$	$\frac{1}{200}$	$\frac{1}{150}$	$\frac{1}{100}$
Engine weighing 8 tons.	25	44	48	56	62	71	87	117
	50	83	91	105	115	131	158	212
	75	122	133	153	148	191	230	307
	100	161	176	201	221	251	302	402
	125	200	218	249	274	311	373	497
	150	239	261	298	327	371	445	592
Engine weighing 10 tons.	25	45	50	58	64	74	91	123
	50	84	93	107	117	134	162	218
	75	123	135	155	170	194	234	313
	100	162	178	203	223	254	306	408
	125	201	220	251	276	314	377	503
	150	240	263	300	329	374	449	598
	175	279	305	348	382	434	521	693
	200	318	348	396	435	494	592	788
Engine weighing 12 tons.	25	46	51	60	67	77	95	129
	50	85	94	109	120	137	166	224
	75	124	136	157	173	197	238	319
	100	163	179	205	226	257	310	414
	125	202	221	253	278	317	381	509
	150	241	264	302	332	377	453	604
	175	280	306	350	385	437	525	699
	200	319	349	398	438	497	596	794
	225	358	392	446	491	557	668	889
	250	397	434	494	544	617	740	984

THE CYLINDER

Is the source from which the motion of an engine is derived, and also the bounds or extent by which the power is determined; hence, some of its various properties require observation and recollection.

1. In diameter it is the most capacious of all plain figures, or contains the greatest area within the same perimeter or outline.

2. The ratio of the diameter is to its circumference as 1 to 3.1416; twice the diameter contains twice the circumference; hence, the piston of a large engine has less rubbing surface, or less friction, according to its power, than a small one.

3. The areas of circles are to each other as the squares of their diameters, or as .7854 to 1: a circle twice the diameter contains four times the area.

EXAMPLE 1.—Required the circumference and area of a circle, or end of a cylinder, 20 inches diameter.

$20 \times 3.1416 = 62.832$ inches circumference.
$20^2 \times .7854 = 314.16$,, area.

EXAMPLE 2.—What is the circumference and area of a circle or piston 40 inches diameter?

$40 \times 3.1416 = 125.664$ inches, or twice 62.832.
$40^2 \times .7854 = 1256.64$,, or four times 314.16.

The whole capacity of a cylinder is equal to the area of the end multiplied by the perpendicular height.

Connected with the preceding remarks on the cylinder, and of equal importance, are the following on steam, in ascertaining the power or effect of an engine:—

In the steam-engine highly rarified steam is of considerably more advantage than steam of a more moderate elastic force. And,

1. On account of the very great increase of force obtained, from a comparatively small increase of heat, as exhibited in the following table :—

Elastic force in atmospheres.	Elastic force in lbs. per sqr. inch.	Degrees of heat.	Difference of temperature	Volume in cubic feet, water being 1.	Velocity into a vacuum in feet per sec.
1	14.7	212° F		1711	1566
2	29.4	250.52	38.52°F	905	1610
3	44.1	275.18	24.66	623	1638
4	58.8	293.72	18.54	479	1658
5	73.5	308.84	15.12	394	1674
6	88.2	320.36	11.52	331	1688
7	102.9	331.70	11.34	288	1700
8	117.6	341.96	10.26	255	1710
9	132.3	350.78	8.82	229	1720
10	147.0	358.88	8.10	209	1729
12	176.4	374.00	15.12	190	1742
15	180.5	392.86	18.86	135	1765
20	294.0	418.45	25.59	111	1786
30	441.0	457.16	38.71	77	1823
50	735.0	510.60	53.44	42	1873

Hence it follows, as a matter of consequence, that, as such small accessions of heat produce so rapid an increase of expansive force, small abstractions of heat from highly elastic steam will also reduce its elasticity in an equal degree, so that high pressed steam is more readily diminished in bulk by the application of cold than weaker steam ; that is, it can be more readily reduced in its pressure to any certain proportion of the pressure it had before.

2. By admitting but a small portion of steam to enter the cylinder, and by its expansive force continue the motion of the piston to the end of the stroke.

When an engine is about to be set in motion, the steam has to overcome the friction and inertia of the whole mass ; but, when once set in motion, the impetus it has acquired continues it in that state for a time, independently of the action of the steam, friction being

only now to overcome; hence, if the steam continue to act as forcibly as at first, it will communicate additional motion to the piston, and will, therefore, perform its stroke with accelerated velocity; but if the supply of steam is cut off at any part of the stroke, the remainder requires to be effected partly by the impetus the piston has already acquired, and partly by the expansion of the steam, its force from this source becoming less just in proportion as the space it occupies increases, thus the motion is in a great measure equalized,—the action of the steam in full strength sets it in motion, and the small and decreasing force requisite to continue the motion at a uniform rate is furnished by the expansion of that steam; the advantage gained by thus economizing the steam increases in proportion as the steam is sooner cut off to the extent indicated in the following table:—

If the steam is stopped at $\frac{1}{n}$ the stroke,	The effect of the quantity of steam admitted is multiplied by 1.7
$\frac{1}{3}$	2.1
$\frac{1}{4}$	2.4
$\frac{1}{5}$	2.6
$\frac{1}{6}$	2.8
$\frac{1}{7}$	3.0
$\frac{1}{8}$	3.2

Thus,—Suppose only one-fourth of the steam necessary to fill the cylinder is employed, the effect produced is more than one-half of the effect which would have been produced in filling the whole cylinder full of steam. Hence, the ratio between the force of the steam giving the first impulse to the piston, and the force of the steam at the termination of the stroke constitutes the uniform elastic force throughout the whole stroke. (For a rule to obtain the uniform force of the steam *see page* 34.)

In calculating the power of an engine, the [illegible] of the piston multiplied by the uniform [illegible] steam,

minus the resistance and friction of the engine, equal the effective moving power; and the effective moving power multiplied by its velocity per minute equal the momentum, or useful effect of the engine; and also, the momentum divided by 150 lbs. × 220 feet, or 33,000 lbs., equal the standard of reference, or number of horses' power.

In high-pressure, or non-condensing-engines, the resistance and friction remain nearly a constant number, namely, 18 lbs. per square inch, including the resistance of the atmosphere. Condensing engines vary with the state of the engine or extent of the vacuum, the mercury in the barometer attached to the condenser frequently ranging between 24 and 28½, or at an average of 26¼ inches; hence, the pressure of the atmosphere being on an average 14.7 lbs. per square inch, and equal to a column of mercury 30 inches in height, 30 : 14.7 : : 26.25 : 12.86 lbs., and 15 − 12.86 = about 2 lbs. resistance to each square inch of the piston's area, besides 8 lbs. required to overcome the friction and inertia of the engine, making the total resistance and friction about 10 lbs. per square inch, or 7.85 lbs. per circular inch of the piston. Hence,

THE GENERAL RULE.

Let D equal the diameter of the cylinder in inches,

F .... uniform force of the steam in lbs. per circular inch of the piston, atmospheric pressure included,

f .... resistance and friction of the engine in lbs. per circular inch,

v .... velocity of the piston in feet per minute,

33000 standard of one horse power,

E the useful effect of the engine expressed in horses' power.

Then 1. $$\frac{D^2 \times \overline{F - r} \times V}{33000} = P$$

And 2. $$\sqrt{\frac{33000 \times P}{V \times \overline{F - r}}} = D.$$

Or, otherwise,—1. Multiply the square of the cylinder's diameter in inches by the uniform force of the steam in lbs. per circular inch, minus the resistance and friction, also per circular inch, and by the velocity in feet per minute; divide the product by 33000, and the quotient is the useful effect of the engine expressed in the term horses' power.

2. Multiply 33000 by the useful effect of the engine, and divide the product by the velocity of the piston in feet per minute, and by the uniform force of the steam in lbs. per circular inch, minus the resistance and friction, and the square root of the quotient equal the cylinder's diameter.

Example 1.—Suppose it be required to ascertain the power of a condensing engine, having the following particulars, namely,

Cylinder 20 inches diameter,
Stroke 4 feet, or 216 feet velocity per minute,
Weight on each circular inch of the safety valve $2\frac{1}{2}$ lbs. or 11.78 + 2.5 = 14.28 lbs. atmospheric pressure included.
Steam cut off from the cylinder when the piston has moved $\frac{2}{3}$rds of the stroke, or 32 inches.
Resistance and friction 10 lbs. per square inch, or 7.85 lbs. per circular inch; required the useful effect of the engine in horses' power.

$\frac{48}{32} = 1.5$, and $\frac{14.28}{1.5} = 9.52$. The hyperbolic *logarithm of* $1.5 + 1 = 1.40546 \times 9.52 = 13.37$ lbs.

per circular inch of uniform elastic force, and 13.37 — 7.85 = 5.52 lbs. effective force; hence,

$$\frac{20^2 \times 5.52 \times 216}{33000} = \frac{476928}{33000} = 14.4 \text{ horses' power.}$$

Example 2.—Required the diameter of the cylinder for a condensing engine of 14.4 horses' power, and also the weight on each circular inch of the safety valve, in order to produce steam of 13.37 lbs. uniform elastic force, the steam to be cut off from the cylinder when the piston has moved 32 inches of its stroke—velocity of the piston 216 feet per minute—resistance and friction 7.85 lbs. per circular inch; 13.37 — 7.85 = 5.52 lbs. effective power of the steam per circular inch; hence,

$$\sqrt{\frac{33000 \times 14.4}{216 \times 5.52}} = \frac{475200}{1192} = \sqrt{400} = 20 \text{ in dia.}$$

Again, 4 feet = 48 inches, and $\frac{48}{32} = 1.5$; the hyperbolic logarithm of 1.5 plus 1 = 1.4054; hence, $\frac{13.37 \times 1.5}{1.4054} = 14.28$ lbs. total force of steam in the boiler per circular inch; and 14.28 — 11.78, or the pressure of the atmosphere = 2.5 lbs. effective elastic force or weight upon each circular inch of the safety valve.

Example 3.—What is the power of a non-condensing engine, having a cylinder of 9 inches diameter, a stroke of 2 feet, or 200 feet velocity per minute, and a pressure of steam in the boiler of 40 lbs. per square inch, atmospheric pressure included, the steam to be stopped off from the piston at half stroke, and the resistance, friction, &c. 18 lbs. per square inch, or 14.1 lbs. per circular inch on the piston's area?

40 lbs. per square inch = 31.4 lbs. per circular inch, $\frac{24}{12} = 2$, and $\frac{31.4}{2} = 15.7$, the hyperbolic logarithm of 2 plus 1 = 1.693 × 15.7 = 26.6 lbs. uniform force of the steam per circular inch, and 26.6 — 14.1 = 12.5 lbs. effective force on each circular inch of the piston;

$$\text{hence, } \frac{9^2 \times 12.5 \times 200}{33000} = 6.1 \text{ horses' power.}$$

EXAMPLE 4.—Let it be required to construct a non-condensing engine of 6.1 horses' power, the uniform elastic force of steam to be 26.6 lbs. per circular inch in the cylinder, when cut off—at half stroke, piston's velocity 200 feet per minute, resistance and friction 14.1 lbs. per circular inch; required the cylinder's diameter in inches, and also the pressure of the steam on each circular inch of the boiler above the pressure of the atmosphere.

26.6 lbs. elastic force, minus 14.1 resistance and friction, = 12.5 lbs. effective pressure per circular inch; hence,

$$\sqrt{\frac{33000 \times 6.1}{200 \times 12.5}} = 9 \text{ inches diameter.}$$

Again, $\frac{24}{12} = 2$, the hyperbolic logarithm of 2 plus 1 = 1.693, and $\frac{26.6 \times 2}{1.693} = 31.4 - 11.78 = 19.62$ lbs. per circular inch, or 25 lbs. per square inch in the boiler above the pressure of the atmosphere.

The preceding may be taken as the real effect of an engine, expressed in the usual term, *horses' power;* but there exist various nominal and approximate rules, whereby the diameter of a cylinder, or power of an *engine, is* determined, but governed in a great measure

by competition,—one maker endeavouring to excel another, by increasing the effect of the engine and retaining the same nominal power, which is not unfrequently supposed the result of superior mechanism, or some very essential interior intricacy, although, generally, at the expense of a larger cylinder, or an increased force of steam.

However, the following are selected as those most commonly used, and what custom has rendered almost a general standard, the more so, no doubt, on account of being considered to have originated from the celebrated firm of Boulton and Watt.

In this rule the steam in the boiler is supposed at a constant pressure of about 3.18 lbs. per square inch, or 2.5 per circular inch; the piston at a constant or uniform velocity of 220 feet per minute; and the effective force on the piston about 7.5 lbs. per square inch, or 5.89 lbs. per circular inch; and under such circumstances 30 circular inches are considered an equivalent to one horse power, when the beam for communicating the motion from the piston is about 3, and the connecting rod not less than 2.5 times the length of the stroke.

But marine engines are generally confined, the connecting rods being seldom more than from 1.75 to twice the length of stroke, and, as a compensation for this disadvantage, the area of the piston is augmented to 31.5 circular inches to each horse power.

Again, small packets for rivers, &c., are still more confined, being often compelled to have the connecting rods not more than from 1.25 to 1.5 times the length of stroke, causing a very acute angle with the crank; in such, not fewer than 34 circular inches is considered equal to one horse power.

In high-pressure, or non-condensing engines, one-third the force of the steam is deducted for resistance of the atmosphere, friction, &c.; hence, as in condensing engines, $30 \times 5.89 = 176.7$ lbs. effective pressure equal the amount of one horse power; consequently,

steam at 25 lbs. per square inch, or 19.63 lbs. per circular inch, minus $\frac{1}{3}$rd, $= \frac{19.63 \times 2}{3} = 13.08$ lbs. effective pressure on each circular inch of the piston's area, and $176.7 \div 13.08 = 13.6$ circular inches to each horse power.

Steam at 30 lbs. per square inch $= 23.56$ lbs. per circular inch, and $\frac{23.56 \times 2}{3} = 15.7$ lbs. effective pressure; hence, $176.7 \div 15.7 = 11.3$ circular inches to each horse power.

Steam at 40 lbs. per square inch $= 31.41$ lbs. per circular inch, and $\frac{31.41 \times 2}{3} = 20.94$ lbs. effective pressure; hence, $176.7 \div 20.94 = 8.5$ circular inches to each horse power.

Steam at 50 lbs. per square inch $= 39.27$ lbs. per circular inch, and $\frac{39.27 \times 2}{3} = 26.18$ lbs. effective pressure; hence, $176.7 \div 26.18 = 6.8$ circular inches to each horse power;—and the same at any other pressure that might be required.

EXAMPLE 1.—Required the diameter of a cylinder for a land condensing engine of 36 horses' power.

$$\sqrt{36 \times 30} = 32.86 \text{ inches diameter.}$$

EXAMPLE 2.—What is the nominal power of an engine, the cylinder of which is 32.86 inches diameter?

$$32.86^2 \div 30 = 36 \text{ horses' power.}$$

EXAMPLE 3.—Required the diameter of the cylinder for a marine engine of 65 horses' power.

$$\sqrt{65 \times 31.5} = 45.25 \text{ inches diameter.}$$

EXAMPLE 4.—The diameter of the cylinder of a ma-

rine engine is 45.25 inches diameter; required the nominal power of the engine.

$$45.25^2 \div 31.5 = 65 \text{ horses' power.}$$

EXAMPLE 5.—The force of the steam in a boiler is 30 lbs. per square inch above the pressure of the atmosphere; if it were applied to a non-condensing engine, so as to produce a power equal to 6 horses, what must be the cylinder's diameter?

$$\sqrt{11.3 \times 6} = 8.25 \text{ inches diameter.}$$

EXAMPLE 6.—The diameter of the cylinder of a non-condensing engine is 8.25 inches, and the steam at 30 lbs. per square inch, required the engine's power.

$$8.25^2 \div 11.3 = 6 \text{ horses' power.}$$

Table containing the difference between a certain elastic force of steam on a square and circular inch.

Steam with an elastic force of	lbs. on a square inch, equal	lbs. on a circular inch, and require to be maintained at a temperature of	Steam with an elastic force of	lbs. on a circular inch, equal	lbs. on a square inch, and require to be maintained at a temperature of
2.5	1.96	220° F	2.5	3.18	222.5° F
3	2.35	222	3	3.82	224.5
3.5	2.75	223.5	3.5	4.45	226.5
4	3.14	225	4	5.09	228.5
4.5	3.53	227	4.5	5.73	230.5
5	3.92	228	5	6.36	232
5.5	4.32	230	5.5	7.00	234
6	4.71	231.5	6	7.64	235.5
6.5	5.10	233	6.5	8.27	236.5
7	5.49	234	7	8.91	238.5
7.5	5.89	235	7.5	9.55	239.5
8	6.28	236	8	10.18	241
9	7.06	239	9	11.45	244
10	7.85	240	10	12.73	247
12	9.42	245.5	12	15.27	252.5
15	11.78	251	15	19.09	259
20	15.71	260	20	25.46	270
25	19.63	268	25	31.83	278.5
30	23.56	275	30	38.19	287
35	27.49	282	35	44.56	294
40	31.41	288	40	50.92	300.5
45	35.34	294	45	57.29	305
50	39.27	299	50	63.66	309

The preceding questions are very conveniently obtained by the sliding rule.

1. By the engineer's improved sliding rule.—Set 1 upon B to the number of circular inches allowed to a

horse power upon A, and against the number of horses' power upon C is the cylinder's diameter in inches upon D; or, against the cylinder's diameter in inches upon D is the number of horses' power upon C.

Thus, set 1 upon B to 30 upon A, and against any number of horses' power upon C is the diameter in inches upon D, for common condensing engines.

2. By the common sliding rule.—Set 1 upon C to the diameter of a cylinder equal to 1 horse power upon D, and against any diameter upon D is the number of horses' power upon C; or, against any number of horses' power upon C is the diam. of the cylinder in in. upon D.

NOTE.—The square root of *any number* of circular inches to a horse power equal *the diameter*;—thus $\sqrt{30} = 5.47$ inches,—$\sqrt{31} = 5.6$ inches,—$\sqrt{34} = 5.8$ inches, being the diameters of cylinders of 1 horse power, for land and marine condensing engines; And $\sqrt{3.6} = 13.7$ inches,—$\sqrt{11.3} = 3.4$ inches,—$\sqrt{8.5} = 2.9$ inches,—and $\sqrt{6.8} = 2.6$ inches, or the diameter of cylinders for non-condensing engines of 1 horse power, with steam above the pressure of the atmosphere equal to 25, 30, 40, and 50 lbs. per square inch.

EXAMPLE 1.—What diameter must a cylinder be for a condensing engine to equal 20 horses' power?

Set 1 upon B to 30 upon A, and against 20 upon C is $24\frac{1}{2}$ upon D.

When the rule is thus set, C is a line of horses' power, and D a line of diameters for cylinders corresponding to that power.

EXAMPLE 2.—What number of horses' power will a high pressure engine be equal to when the cylinder is 12 inches diameter, and steam 30lbs. per square inch?

Set 1 on B to 11.3 upon A, and against 12 upon D is 12.7 horses' power upon C.

Suppose the same to be required upon the common slide rule.

1.—Set 1 upon C to 5.47 upon D, and against 20 *upon C is* $24\frac{1}{2}$ upon D.

2.—Set 1 upon C to 3.4 upon D, and against 12 upon D is 12.7 upon C.

The following tables exhibit various proportions for engines, estimated according to their nominal power.

Table 1.—*Land Condensing Engines.*

Number of horses' power.	Diameter of cylinder in inches.	Area of apertures to the cylinder in inches.	Proportionate length of stroke in feet and in. for portable engines.	Proportionate length of stroke in feet and inches for fixed engines.	Number of strokes per minute.	Diameter of air pump in inches.	Diameter of cold water pump in inch. at $\frac{3}{4}$ stroke.	Diameter of feed pump in inches at $\frac{1}{4}$ stroke.	Cubic feet of water per hour for condensation.	Lbs. of good coal required per hour.
			ft. *in*	*ft.* *in*						
4	12	5	2 0		55	8	$3\frac{1}{2}$	$1\frac{3}{8}$	56	56
5	$13\frac{3}{4}$	6	6		44	$8\frac{3}{4}$	$3\frac{3}{4}$	$2\frac{1}{4}$	75	65
6	$14\frac{1}{2}$	7		3 0	37	$9\frac{1}{2}$	$4\frac{1}{8}$	$2\frac{3}{8}$	90	74
8	$16\frac{1}{2}$	9	3 0		37	$10\frac{1}{2}$	$4\frac{5}{8}$	$2\frac{1}{2}$	113	90
10	18	11		3 6	32	12	5	$2\frac{5}{8}$	158	102
12	$19\frac{1}{2}$	13	3 6	4 0	28	13	$5\frac{1}{8}$	$2\frac{7}{8}$	187	120
14	21	15		4 6	25	14	6	3	226	128
16	$22\frac{1}{2}$	17	4 0		28	15	$6\frac{1}{4}$	$3\frac{1}{4}$	264	144
18	$23\frac{3}{4}$	19		5 0	22	$15\frac{3}{4}$	$6\frac{1}{2}$	$3\frac{3}{8}$	302	158
20	$24\frac{1}{2}$	21			22	$16\frac{1}{4}$	7	$3\frac{5}{8}$	338	170
22	26	23	4 6		25	$17\frac{1}{2}$	$7\frac{1}{4}$	$3\frac{3}{4}$	380	186
24	27	24		5 6	20	18	$7\frac{3}{4}$	$3\frac{7}{8}$	420	190
25	$27\frac{1}{2}$	25			20	$18\frac{1}{4}$	$7\frac{5}{8}$	$4\frac{1}{8}$	450	200
26	28	26	5 0	6 0	19	$18\frac{1}{2}$	8	$4\frac{1}{4}$	480	212
28	29	28			19	$19\frac{1}{4}$	$8\frac{1}{4}$	$4\frac{1}{8}$	520	220
30	30	30			19	20	$8\frac{1}{2}$	$4\frac{3}{8}$	560	236
35	$32\frac{1}{2}$	35		6 6	17	$21\frac{3}{4}$	$9\frac{1}{4}$	$4\frac{7}{8}$	712	268
40	$34\frac{1}{2}$	40			17	23	10	$5\frac{1}{8}$	940	292
50	$38\frac{1}{2}$	50		7 0	16	$25\frac{1}{2}$	$11\frac{1}{4}$	$5\frac{3}{4}$	1120	346
60	$42\frac{1}{4}$	60			16	28	12	6	1225	408

NOTE.—When the fly wheel shaft is of cast iron, the diameter of the bearings is the same as the diameter of the cold water pump.

Table 2.—Marine Engines.

ENGINES WHOSE CONNECTING RODS ARE NOT LESS THAN 1½ TIMES THE LENGTH OF STROKE.			ENGINES WHOSE CONNECTING RODS ARE LESS THAN 1½ TIMES THE LENGTH OF STROKE.		
Number of horses' power.	Diameter of cylinder in inches.	Diameter of air pump in inches.	Number of horses' power.	Diameter of cylinder in inches.	Diameter of air pump in inches.
25	28	16	10	18½	12
30	3[illegible]	17[illegible]	12	20½	13½
35	33½	19[illegible]	14	22	14½
40	35½	20[illegible]	15	22½	14½
45	37½	21[illegible]	16	23½	15½
50	39½	22½	18	24½	16½
55	41½	24	20	26	17
60	43½	25	25	29½	19½
65	45½	26	30	32	21
70	47	27	35	34½	22½
75	48½	28	40	37	24½
80	50½	29	45	39½	25½
85	51½	29½	50	41½	27
90	53½	30½			
95	54½	31½			
100	56½	32½			
110	59	34			
120	61½	35½			
130	64	37			
150	68½	39½			
200	79½	45½			

Table 3.—Non-condensing or High-pressure Engines.

Number of horses' power.	Diameter of cylinder in inches,—steam at 25 lbs. per square inch.	Diameter of cylinder in inches,—steam at 30 lbs. per square inch.	Diameter of cylinder in inches,—steam at 40 lbs. per square inch.	Diameter of cylinder in inches,—steam at 50 lbs. per square inch.
1	3⅜	3½	3	2⅜
2	5⅜	4½	4¼	3⅜
3	6½	6	5	4⅛
4	7½	6⅜	6	5¼
6	9	8¼	7¼	6⅛
8	10½	9⅜	8⅜	7⅛
10	11⅜	11	9⅜	8⅜
12	13	12	10⅜	9¼
14	14	12⅜	11¼	10
16	15	13⅜	12	10⅛
18	15⅜	14¼	12⅜	11¼
20	16⅜	15¼	13⅜	11⅜
25	18½	17¼	15	13¼
30	20¼	19¼	16¼	14½
Quantity of water in gallons per minute to each horse power,	.45	.5	.61	.73

To ascertain the power or effect of a locomotive engine.

The efficiency of a locomotive engine depends upon the force of the steam, the area of the cylinders, and the ratio existing between the length of the stroke and the diameter of the wheels; also, the resistance of the atmosphere, and friction of the engine, which is on an average 15 lbs. per ton;—hence, by the following simple formula, the various effective proportions may be determined, and also the amount of useful effect produced from a certain given force of steam.

Let W represent the weight of the load in gross tons, tender included,

9 .....resistance of the load per ton,

F or 15 .....resistance and friction of the engine per ton,

D .....diameter of the wheels in feet,

d .....diameter of the cylinders in feet, or parts of a foot,

l .....length of stroke, also in feet or parts of a foot,

P .....total pressure of steam in the boiler per square foot, atmospheric pressure included,

p .....atmospheric pressure per sqr. foot, or 2117 lbs.: hence, $P - p =$ the effective pressure,

S .....quantity of water evaporated per hour in cubic feet,

r .....ratio of the volume of steam, water being 1, or the volume of steam to the volume of water that produced it,

And V .....velocity of the engine in feet per hour.

1. $\frac{P\,r\,S\,D - p\,d^2\,l\,V}{V\,9\,D} - \frac{F}{9} = W$, or the load in

gross tons, tender included, that a given engine will draw, with a known pressure and a determined velocity.

2. $\frac{(P-p)\,d^2\,l}{9\,D} - \frac{F}{9} = W$, or the maximum weight that an engine is able to draw at a determined pressure, in gross tons, tender included.

3. $\sqrt{\frac{D\,(9\,W + F)}{(P-p)\,l}} = d$, or the cylinder's diameter in feet or parts of a foot, in order that, if necessary, it may draw a certain maximum load.

4. $\frac{D\,(9\,W + F)}{(P-p)\,d^2} = l$, or the length of stroke in feet, so that a proper ratio may exist between the stroke and the wheels, to enable the engine to produce the same effect of maximum load.

5. $\frac{(P-p)\,d^2\,l}{9\,W + F} = D$, or the diameter of the wheels that an engine must have in order to render it able to draw a fixed or maximum load.

To illustrate the preceding formula by example,—Suppose an engine of the following proportions:—

Diameter of cylinders 11 inches, or .917 feet,
Length of stroke 16 inches, or 1.33 feet,
Diameter of wheels 5 feet,
Weight of engine 8 tons,
Quantity of water evaporated per hour, 38.74 cubic feet,
And Effective pressure 50 lbs. per square inch; what are the various effects and proportions, as might be required?

In the present case,

$P = 144 \times 65 = 9360$ lbs., or the pressure of steam per square foot, atmospheric pressure included,

$p = 2117$ lbs., or the pressure of the atmosphere per square foot, and

$P - p = 7243$ lbs. effective pressure per square foot,

$F = 15 \times 8 = 120$, or the resistance and friction of the engine, and

$r = 435$ (*see Table, page* 20.) Hence,

Ex. 1. Required the load an engine of this description will take upon a level, at the rate of 20 miles per hour.

20 miles = 105600 feet, then

$$\frac{144 \times 65 \times 435 \times 38.74 \times 5 - 2117^2 \times .917 \times 1.33 \times 105600}{105600 \times 9 \times 5} =$$

$$113.13 - \frac{120}{9} = 100 \text{ tons gross weight, tender included.}$$

Ex. 2. What is the maximum load for an engine of the preceding proportions, and steam at 50 lbs. per square inch, effective pressure?

$$\frac{\overline{9360 - 2117} \times .917^2 \times 1.33}{9 \times 5} = 180 - \frac{120}{9} = 166.7$$

tons gross weight.

Ex. 3. What must be the diameter of the cylinders for a locomotive engine as above, so that it may be enabled to draw a load of 166.7 tons?

$$\sqrt{\frac{166.7 \times 9 + 120 \times 5}{\overline{9360 - 2117} \times 1.33}} = .917 \text{ of a foot, or } 11$$

inches diameter.

Ex. 4. Required the length of stroke, so as to render

this engine capable of drawing 166.7 tons, with wheels of 5 feet diameter.

$$\frac{166.7 \times 9 + 120 \times 5}{9360 - 2117 \times .917^2} = 1.33 \text{ feet, or } 16 \text{ inches,}$$

length of stroke.

Ex. 5.—What must be the diameter of the wheels for a locomotive engine, in order that it may be able to draw a given maximum load, the other proportions being the same as above?

$$\frac{9360 - 2117 \times .917^2 \times 1.33}{166.7 \times 9 + 8 \times 15} = 5 \text{ feet diameter.}$$

The following Table contains the diameters of cylinders, with a given pressure of steam, to draw certain maximum loads:—

Particulars of the Engine.	Load in gross tons tender included.	Diameter of Cylinders in inches, with steam at 50lbs. 55lbs. & 60 lbs. per sq. inh in the boiler.		
Wheels 5 feet. Stroke 16 inches, or 1.33 feet. Weight 8 to 10 tons.	100	9 in.	8½ in	8 in.
	125	9¾	9¼	9
	150	10⅝	10	9⅝
	175	11¼	11	10¼
	200	12	11½	11
	225	12⅝	12⅛	11⅝
	250	13⅜	12¾	12¼
Wheels 5 feet. Stroke 16 inches, or 1.33 feet. Weight 10 to 12 tons.	200	12¼	11⅞	11½
	225	13	12¼	12
	250	13½	13	12½
	275	14⅛	13½	13
	300	14⅝	14	13½
	325	15¼	14⅝	14
	350	16	15⅜	14½
Wheels 5 feet. Stroke 18 inches, or 1.5 feet. Weight 11 to 13 tons.	200	11½	11	10½
	225	12⅛	11½	11
	250	12⅝	12⅛	11⅝
	275	13¼	12⅝	12⅛
	300	14	13⅛	12⅝
	325	14½	13⅝	13⅛
	350	15	14¼	13⅝

THE NOZZLES, FRONT PIPES, OR SLIDE VALVES,

Are for the purpose of alternate admission of steam to and from the cylinder of a steam-engine, and consist of either *conical valves*, *slide valves*, or *cocks*, the motion of which is derived from the engine by various means, as *tappets*, *eccentrics*, *cambs*, &c., and by such means various effects are produced; however, practice has sufficiently decided the superiority to tappets, or hand gear, as the means by which the most effective power of an engine can be obtained,—but their unpleasant noise and greater liability of derangement prevent their more frequent application; hence, to render the eccentric more effective, the *apertures* or steam openings to the cylinder are of a certain proportion, and made as long as the cylinder's diameter will properly admit, so that by a smaller movement of the valve a greater opening may be gained. In condensing engines the area of each opening or steam way equal $\frac{1}{10}$th, and non-condensing or high-pressure engines $\frac{1}{16}$th of the square of the cylinder's diameter.

And, as a farther means of enabling the eccentric to approximate hand gear, the valve or valves are placed at a certain distance in advance of the piston, and termed by engineers *the lead of the valve*, so that at each return of stroke the steam in the cylinder may sooner approach an equal density to the steam in the boiler; but an excess of lead is only advantageous to engines lightly loaded, and an increased velocity required. When such is the case, a proper impulse of steam at the commencement of the stroke, and again sooner cut off, is of considerably more advantage than steam gradually applied, and in a similar way continued to the end of the stroke; hence, the propriety of lead for the valves of engines on board steam-packets for carrying *passengers;*

and also the valves of locomotive engines for running *passenger trains*, &c., for the velocity is increased in nearly the following proportion :—

When the lead of the valve is 0 the velocity = 1.
..... $\frac{1}{8}$ inch ..... = 1.016.
..... $\frac{1}{4}$ ..... = 1.048.
..... $\frac{3}{8}$ ..... = 1.103.

But by such means the maximum effect of an engine may be considerably lessened, for it is the pressure and quantity of steam which constitute the power, and in proportion as the lead of the valve is increased so is the length of stroke, or quantity of steam diminished by being sooner cut off,—consequently, the power of the engine reduced; for which reason, other means are frequently resorted to, whereby to effect a greater advantage of the steam during the stroke, otherwise than by the lead of the valve. Among the most practical for that purpose is the *camb* or *tumbler*, a modification of which was tried upon several locomotive engines on the Leeds and Selby Railway, with a beneficial effect, whilst they kept in proper condition, but on account of the motion being so great the proper form of the camb was soon destroyed, the other became disarranged, and the valves not opened to their proper extent, in consequence of which the system was abandoned; but the effect is good when applied to engines with longer strokes, where the changing motion of the parts are not so rapid.

In order further to illustrate the advantage and disadvantage to an engine by the lead of the valve, the following table is annexed, as the result of experiments on the Liverpool and Manchester Railway, by C. de Pambour, and which I find in practice nearly to coincide:—

Particulars of the Engine.	Load in gross tons tender included.	Velocity in miles per hour, the lead of the valve being			
		0	$\frac{1}{8}$ in.	$\frac{2}{8}$ in.	$\frac{3}{8}$ in.
	tons.	miles.	miles.	miles.	miles.
Diameter of cylinders 11 in.	50	31.02	31.52	32.51	34.23
Stroke 16 inches.	100	21.68	22.02	22.72	23.92
Wheels 5 feet.	141	17.39	17.66	18.22	19.18
Effective pressure 50 lbs.	155	16.28	16.54	17.06	0.
per square inch.	163	15.72	15.96	0.	0.
	165	15.53	0.	0.	0.
	50	27.80	28.24	29.13	30.68
Diameter of cylinders 12 in.	100	20.05	20.37	21.01	22.12
Stroke 16 inches.	150	15.68	15.93	16.43	17.30
Wheels 5 feet.	168	14.56	14.79	15.25	16.06
Effective pressure 50 lbs.	183	13.72	13.94	14.38	0.
per square inch.	193	13.22	13.43	0.	0.
	196	13.11	0.	0.	0.
	50	26.16	26.57	27.41	28.86
Diameter of cylinders 12 in.	100	19.35	20.16	20.80	21.90
Stroke 18 inches.	150	15.99	16.24	16.75	17.64
Wheels 5 feet.	188	13.93	14.15	14.60	15.37
Effective pressure 50 lbs.	207	13.09	13.30	13.72	0.
per square inch.	217	12.69	12.89	0.	0.
	221	12.53	0.	0.	0.

Again, *the lap or cover of the valve* is a certain additional breadth of its face on the steam side, more than the width of the aperture to the cylinder, for the purpose of cutting off the steam at any determined part of the stroke, and which is of considerable advantage in condensing engines, when steam of greater elastic force is employed than is necessary to be continued throughout the whole stroke. In our present practice, the lap for land engines is from $\frac{1}{2}$ inch to $\frac{5}{8}$, with steam of $3\frac{1}{2}$ to 4 lbs. per square inch above the pressure of the atmosphere. But the lap for marine engines varies from $\frac{3}{8}$ to $1\frac{3}{4}$ inches, according to the elastic force of the steam, ranging from 4 to 10 lbs. per square inch,—for the calculated advantage of which *see page* 45. Locomotive engines and non-condensing engines, in general, with short strokes, require no more lap than just perceptibly covers the apertures to the cylinder when the valve is at the middle of the stroke.

ECCENTRICS, CAMBS, &c.

An *eccentric* is a contrivance by which continued circular motion is converted into alternate rectilinear motion; and, in like manner, by the *camb*, is uniform rotatory motion converted to a varied rectilinear motion; hence, their frequent application in the steam-engine for giving motion to the valves, whereby the direction of the steam is alternately changed, and also the quantity regularly proportioned.

1. *To construct an eccentric of the usual form for a steam-engine.*

Upon a straight line with the radius of the shaft describe the circle or eye of the eccentric *a b*; describe, also, the circle *e c*, or necessary thickness of metal around the shaft, for the boss; make *c* to *d* equal the travel of the valve or required throw of the eccentric; bisect *e d* in *n*, and form *n* as a centre, with the radius *n e* or *n d*, describe the diameter of the eccentric as required.

2. *To construct a camb as applicable to the steam-engine.*

Describe the circle *a b* equal to the diameter of the shaft on which it is to be fixed; also, the circle *e c*, or thickness of metal round the shaft by which it is to be fixed; make *c d* equal to the travel of the valve or required throw of the camb; draw the line *p r* at right angles with the line *c d*, and distant from *d* three-fourths of the radius *e n* or *n c*; bisect *e d*, and with the same distance from where the lines intersect each other set off *s p* and *s r*; on the line *p r*, with one-fourth of the radius *e n* or *n c*, set off *p* 1 and *r* 1; draw the lines 2 2

and 3 3; from 1, with the radius 1 *r*, describe *r* 2 and *p* 3; also, from 1, with the distance 1 3, describe 3 *r* and 2 *p*, and from *n*, with the distance *n d*, describe 2 *d* 3, which constitute the camb required.

But the throw of the eccentric in a steam engine is not particularly required to equal the travel of the valve, for the direction of the motion generally requires to be changed by levers, which may be made unequal lengths at pleasure.

Hence, let *t* represent the travel of the valve,
L ..... the length of the lever to which the eccentric rod is attached,
E ..... the throw of the eccentric,
And *l* ..... the length of the lever for giving motion to the valve;

Then, 1. $\frac{t\,\mathrm{L}}{l} = \mathrm{E}$. 2. $\frac{t\,\mathrm{L}}{\mathrm{E}} = l$. 3. $\frac{\mathrm{E}\,l}{t} = \mathrm{L}$. 4. $\frac{\mathrm{E}\,l}{\mathrm{L}} = t$.

EXAMPLE.—Suppose $t = 8$ inches.
$\mathrm{L} = 6$,,
$\mathrm{E} = 4$,,
$l = 12$,,

1. $\frac{8 \times 6}{12} = 4$ inches, throw of eccentric.

2. $\frac{8 \times 6}{4} = 12$ inches, length of lever for giving motion to the valve.

3. $\frac{4 \times 12}{8} = 6$ inches, length of lever at the end of eccentric rod.

4. $\frac{4 \times 12}{6} = 8$ inches, or the travel of the valve.

THE CONDENSER, COLD WATER PUMP, AND AIR PUMP.

When steam is exposed to any degree of cold its heat is abstracted,—its elastic force diminished; and, in proportion to the intensity or quantity of cold, is sooner or later condensed, and re-assumes the state of water, by which its bulk is reduced nearly 2000 times. Hence the principal property in the condensing engine.

Various means have been employed whereby condensation might sooner be effected in the steam-engine, and a more perfect vacuum obtained, but nothing as yet has superseded a jet of cold water, hence the necessity of a condenser and air pump in marine engines, and also the necessity for a condenser, cold water pump, and an air pump in land engines generally.

The capacity of the condenser ought to be as large as circumstances will conveniently admit, and not less than one-eighth the capacity of the cylinder; but, in marine engines, where the bottom of the condenser and bottom of the cylinder are on nearly the same line, care must be taken in making the passage between the valves and condenser large enough to contain the condensing water required for one stroke of the piston, besides leaving a proper communication, otherwise the connexion between the cylinder and air pump will be cut off by water of nearly 100° of heat, on account of the cylinder being twice filled with steam for each effective stroke of the air pump.

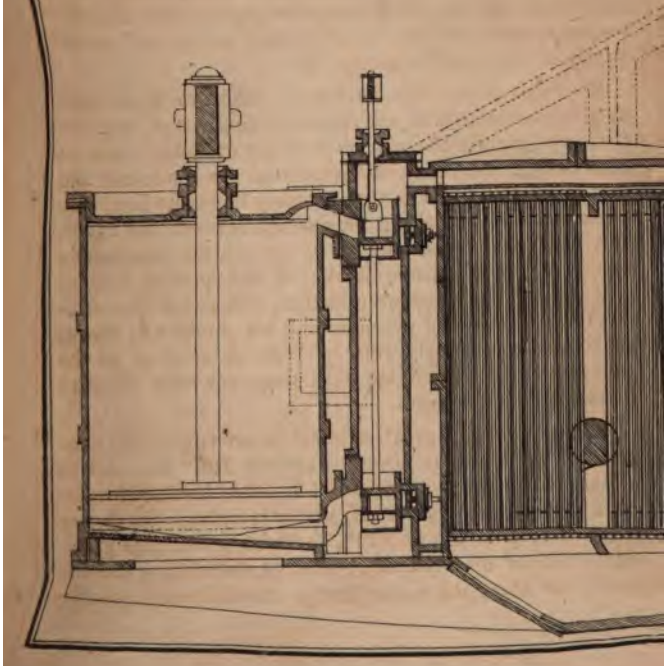
To produce the greatest effect in an engine the condensed water ought never to exceed 100° Ft., and to obtain this point requires about 30 cubic inches of water at a mean temperature of the atmosphere for every cubic foot of steam at 220°, to which point it is generally reduced or expanded; but, in calculating for the capacity of the cold water pump, an additional quantity

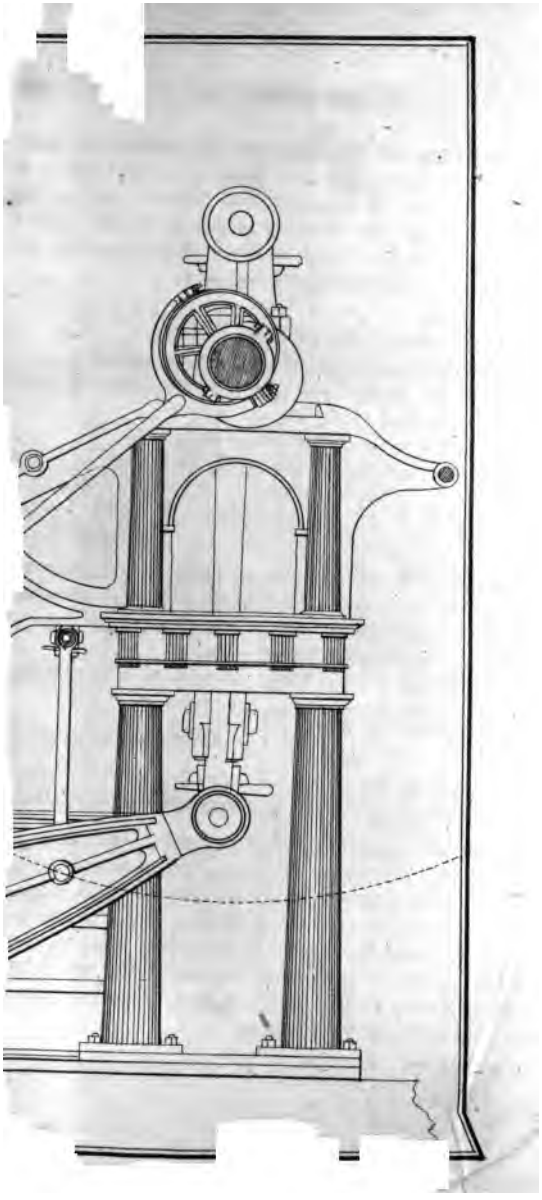
ELEVATION AND SECTION O

75 HORSE MARINE ENGINE

HALL'S PATENT CONDEN

Scale 9/16ths of an Inch to a Foot.





l for imperfections, uncertainty of tem-
ence, not less than 35 cubic inches, or
s, is considered sufficient; and as the
y one effective stroke while the piston
e the length of stroke multiplied by the
the cylinder's capacity.

a of the cylinder in feet,
he length of stroke also in feet,
inches the quantity of water to each
oot of steam,
roke of the pump in inches,
ameter of the pump in inches,

$\frac{A\ S\ 45}{l} = d.$ and $\frac{A\ S\ 45}{d^2} = l.$

What diameter of pump is necessary for
cylinder 30 inches, or $2\frac{1}{2}$ feet diameter,
d the stroke of the pump to equal half
engine, or 36 inches?
r = 4.9 feet. Stroke × 2 = 12 feet.

$\frac{) \times 12 \times 45}{36} = 8.25$ inches diameter.

$\frac{12 \times 45}{.55} = 36$ inches length of stroke.

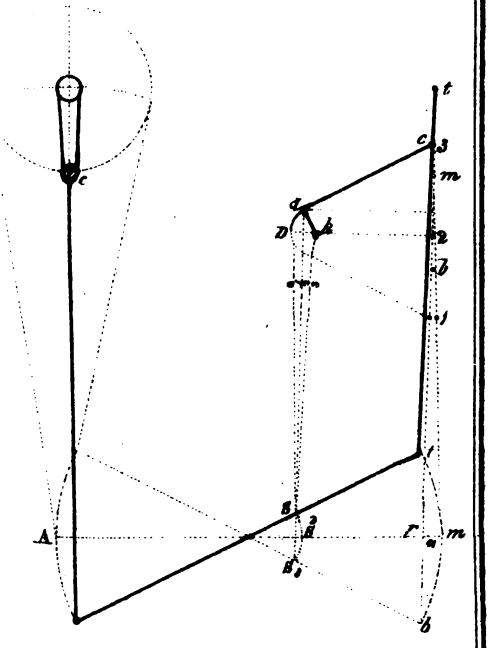
pump is for the purpose of extracting or
ondenser of water, uncondensed steam,
accumulate in the act of condensation.
and engines is about $\frac{1}{4}$th the capacity of
d in marine engines $\frac{1}{3}$th. Hence, sup-
er of a land engine equal 20 inches
4 feet, or 48 inches; required the air
at half stroke.

$= \sqrt{200} = 14.14$ inches diameter.

$$-34 = 44 \text{ and } 44^2$$

inch

Fig 3rd. *A motion that is chiefly used in marine Engines*



Or, required the diameter of air pump for a marine engine with a cylinder 36 inches diameter, stroke $3\frac{1}{2}$ feet, and the studs by which the pump bucket is to be worked placed 36 inches from the ends of the levers, the radius, or half length of the levers, being 5 feet.

Radius of beams or levers 60 inches, stroke 42 inches,
Radius of pump studs 24 inches,

Then, as
60 : 42 :: 24 : 16.8 inches, or stroke of the pump.

And $\frac{36^2 \times 42}{5 \times 16.8} = \sqrt{648} = 25.48$ inches diameter.

THE PARALLEL MOTION, BEAM, &c.

In a *beam engine* the parallel motion is the link or connexion between the top of the piston rod and end of the beam, and also the means by which the piston rod is made to move in a direct line; hence, according as the beam is differently situated in the engine, so must the motion be differently modified to suit—*(see Table of Parallel Motions)*—but in whatever situation the beam or levers may be placed, the principle of the motion remains the same, and its correctness depends entirely upon the radius rods being of a proper length, which may be obtained by the following general rule :—

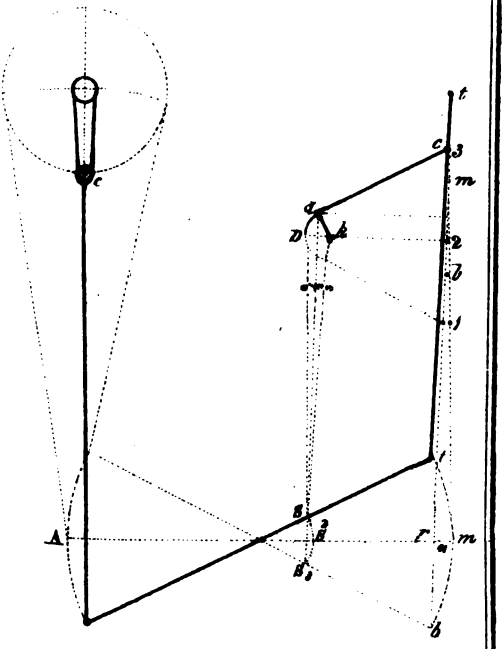
Let R = the radius of the beam,
l = ,, length of parallel bars,
And r = ,, length of radius rods,

Then $\frac{\sqrt{R - l^2}}{l} = r$

Example.—Suppose the radius of a beam equal $6\frac{1}{2}$ feet, or 78 inches, and the length of the parallel bars 34 inches; required the length of radius rods.

$78 - 34 = 44$, and $\frac{44^2}{34} = 56.35$ inches.

Fig 5.rd A motion that is chiefly used in marine Engines



But in marine engines, or engines on the marine principle, the side rods constitute the front links of the motion, having the parallel bars frequently attached at some distance below the end of the cross head—*(see Figure 3, Table of Motions)*—by which different angles are formed, and the preceding rule rendered incorrect. Other suitable rules might be applied, but being, in general, much more tedious, it is better to lay it down in the following geometrical form :—

See Fig. 3.—Upon the line A *m*, with the radius of the beam, describe the arc *b m t*; from *m*, with half the length of stroke, cut the arc in *b* and *t*, draw the line *b t* and *r m* equal the versed sine described by the beam ; bisect *r m* in *n*, and erect a perpendicular line for the centre of the cylinder. Again, from *b m t*, with the length of the side rods, cut the perpendicular line ; at the bottom, middle, and top stroke of the cross-head draw the lines *b b*, *m m*, and *t t*; from the end of the cross-head, or top of the side rods, with any convenient distance, set off the pin or stud in the side rod for the end of the parallel bar 1, 2, 3, from which, with the distance *s t*, describe arcs at *d* D *d*; draw the lines *d* 1, D 2, &c. ; also, with the distance *m* 2, from S S S, cut the former arcs in *d* D *d*, and the radius of the circle, or length of the radius rod, D *k*, is found by the following problem :—

Through any three points out of a right line to describe the circumference of a circle.

From the middle point as a centre, with any convenient distance, describe the circle, or arcs of a circle, as A and B, and from the other points, with the same distance, describe arcs cutting the circle in C D and E F ; draw lines through C D and E F, and where they intersect each other at *o* is the centre of the circle required.

Table containing the length of radius rods for motions with beams and parallel bars of various lengths.

Radius of beam in Ft. & In.	Length of parallel bars in Ft. & In.	Length of radius rods in Ft. & In.	Radius of beam in Ft. & In.	Length of parallel bars in Ft. & In.	Length of radius rods in Ft. & In.
4 0	1 6	4 2	6 6	2 9	5 1⅜
.. ..	1 9	2 10¾	.. ..	3 0	4 1½
.. ..	2 0	2 0	.. ..	3 3	3 3
.. ..	2 3	1 4⅜	.. ..	3 6	2 6½
.. ..	2 6	0 10⅝	.. ..	3 9	2 0½
.. ..	2 9	0 6⅞	.. ..	4 0	1 6⅜
.. ..	3 0	0 4	.. ..	4 3	1 2½
			.. ..	4 6	0 10½
4 6	1 6	6 0			
.. ..	1 9	4 3½	7 0	2 0	12 6
.. ..	2 0	3 1½	.. ..	2 3	10 0½
.. ..	2 3	2 3	.. ..	2 6	8 1½
.. ..	2 6	1 7½	.. ..	2 9	6 7
.. ..	2 9	1 1⅜	.. ..	3 0	5 4
.. ..	3 0	0 9	.. ..	3 3	4 4
.. ..	3 3	0 5½	.. ..	3 6	3 6
			.. ..	3 9	3 2½
5 0	1 6	8 2	.. ..	4 0	2 3
.. ..	1 9	6 0½	.. ..	4 3	1 9
.. ..	2 0	4 6	.. ..	4 6	1 4⅜
.. ..	2 3	3 4⅜	.. ..	4 9	1 0½
.. ..	2 6	2 6	.. ..	5 0	0 9½
.. ..	2 9	1 10½			
.. ..	3 0	1 4	7 6	2 0	15 1½
.. ..	3 3	0 11½	.. ..	2 3	12 3
.. ..	3 6	0 7½	.. ..	2 6	10 0
			.. ..	2 9	8 2⅜
5 6	1 6	10 8	.. ..	3 0	6 9
.. ..	1 9	8 0⅜	.. ..	3 3	5 6⅜
.. ..	2 0	6 1⅜	.. ..	3 6	4 6⅜
.. ..	2 3	4 8⅜	.. ..	3 9	3 9
.. ..	2 6	3 7½	.. ..	4 0	3 0½
.. ..	2 9	2 9	.. ..	4 3	2 6
.. ..	3 0	2 1	.. ..	4 6	2 0
.. ..	3 3	1 6⅜	.. ..	4 9	1 7
.. ..	3 6	1 1⅜	.. ..	5 0	1 3
.. ..	3 9	0 9⅝	.. ..	5 3	0 11½
6 0	2 0	8 0	8 0	2 6	12 1½
.. ..	2 3	6 3	.. ..	2 9	10 0½
.. ..	2 6	4 10½	.. ..	3 0	8 4
.. ..	2 9	3 10	.. ..	3 3	6 11½
.. ..	3 0	3 0	.. ..	3 6	5 9½
.. ..	3 3	2 3⅞	.. ..	3 9	4 9½
.. ..	3 6	1 9½	.. ..	4 0	4 0
.. ..	3 9	1 4⅛	.. ..	4 3	3 3⅜
.. ..	4 0	1 0	.. ..	4 6	2 8⅜
.. ..	4 3	0 8½	.. ..	4 9	2 2½
			.. ..	5 0	1 9⅝
6 6	2 0	10 1½	.. ..	5 3	1 5½
.. ..	2 3	8 0	.. ..	5 6	1 1⅜
.. ..	2 6	6 4⅜			

Table containing the length of radius rods for motions with beams and parallel bars of various lengths.

(CONTINUED.)

Radius of beam in Ft. & In.	Length of parallel bars in Ft. & In.	Length of radius rods in Ft. & In.	Radius of beam in Ft. & In.	Length of parallel bars in Ft. & In.	Length of radius rods in Ft. & In.
8 6	3 0	10 1	10 6	4 0	10 6⅜
.. ..	3 3	8 5⅜	.. ..	4 3	9 2⅝
.. ..	3 6	7 1⅜	.. ..	4 6	8 0
.. ..	3 9	6 0⅛	.. ..	4 9	6 11⅛
.. ..	4 0	5 6⅜	.. ..	5 0	6 0⅛
.. ..	4 3	4 3	.. ..	5 3	5 3
.. ..	4 6	3 6⅜	.. ..	5 6	4 6⅛
.. ..	4 9	2 11⅛	.. ..	5 9	3 11
.. ..	5 0	2 5⅜	.. ..	6 0	3 3⅛
.. ..	5 3	2 0⅛	.. ..	6 3	2 10⅜
.. ..	5 6	1 7⅜	.. ..	6 6	2 5⅜
.. ..	5 9	1 3⅛	.. ..	6 9	2 1
.. ..	6 0	1 0⅛	.. ..	7 0	1 9
9 0	3 0	12 0	11 0	4 6	9 4⅛
.. ..	3 3	10 2	.. ..	4 9	8 2⅛
.. ..	3 6	8 7⅛	.. ..	5 0	7 2⅛
.. ..	3 9	7 4⅛	.. ..	5 3	6 3⅛
.. ..	4 0	6 3	.. ..	5 6	5 6
.. ..	4 3	5 3⅛	.. ..	5 9	4 9⅛
.. ..	4 6	4 6	.. ..	6 0	4 2
.. ..	4 9	3 9⅛	.. ..	6 3	3 7⅛
.. ..	5 0	3 2⅛	.. ..	6 6	3 1⅛
.. ..	5 3	2 8⅛	.. ..	6 9	2 8⅛
.. ..	5 6	2 2⅛	.. ..	7 0	2 3⅛
.. ..	5 9	1 10			
.. ..	6 0	1 6	11 6	4 6	10 10⅛
.. ..	6 3	1 2⅛	.. ..	4 9	9 7
			.. ..	5 0	8 5⅛
9 6	3 6	10 3⅛	.. ..	5 3	7 5⅛
.. ..	3 9	8 9⅛	.. ..	5 6	6 6⅛
.. ..	4 0	7 6⅛	.. ..	5 9	5 9
.. ..	4 3	6 5⅛	.. ..	6 0	5 0⅛
.. ..	4 6	5 6⅛	.. ..	6 3	4 5
.. ..	4 9	4 9	.. ..	6 6	3 10⅛
.. ..	5 0	4 0⅛	.. ..	6 9	3 4
.. ..	5 3	3 5⅛	.. ..	7 0	2 10⅛
.. ..	5 6	2 10⅛	.. ..	7 3	2 6
.. ..	5 9	2 5⅛			
.. ..	6 0	2 0⅛	12 0	5 0	9 9⅛
.. ..	6 3	1 8⅛	.. ..	5 3	8 8⅛
			.. ..	5 6	7 8⅛
10 0	4 0	9 0	.. ..	5 9	6 8⅛
.. ..	4 3	7 9⅜	.. ..	6 0	6 0
.. ..	4 6	6 8⅜	.. ..	6 3	5 3⅛
.. ..	4 9	5 9⅛	.. ..	6 6	4 7⅛
.. ..	5 0	5 0	.. ..	6 9	4 1
.. ..	5 3	4 3⅛	.. ..	7 0	3 6⅛
.. ..	5 6	3 8⅛	.. ..	7 3	3 0⅛
.. ..	5 9	3 1⅛	.. ..	7 6	2 8⅛
.. ..	6 0	2 8	.. ..	7 9	2 4
.. ..	6 3	2 3	.. ..	8 0	2 0
.. ..	6 6	1 10⅛			

The *beam* of an engine during its motion describes a curve more or less, varying with the radius of the beam and length of the stroke, the deviation from the straight line being the versed sine of the arc described by the beam; and in erecting an engine, the centre of the cylinder must be placed directly in a line, or exactly under half the versed sine, so that the angles of the links in the motion may be rendered equal. The versed sine is always equal to the difference of the base and hypotenuse of a triangle, whose hypotenuse equal the radius of the beam and perpendicular half the length of stroke; hence, Add together the radius of the beam and half the length of stroke, multiply the sum by their difference, extract the square root of the product, and the radius of the beam minus the square root equal the versed sine.

EXAMPLE.—Let the radius of a beam equal $7\frac{1}{2}$ feet, or 90 inches, length of stroke 5 feet, or 60 inches; required the versed sine.

$90 + 30 = 120$ and $90 - 30 = 60$, then $\sqrt{120 \times 60} = 84.87$ and $90 - 84.87 = 5.13$ inches, or versed sine.

Or, as an approximate,—Divide the square of half the length of the stroke in inches by twice the radius of the beam, also in inches, and the quotient is the versed sine; thus,

$$\frac{30^2}{90 \times 2} = \frac{900}{180} = 5 \text{ inches.}$$

Table of versed sines for beams and strokes of various lengths.

Radius of beam in Ft. & In.	Length of stroke in Ft. & In.	Versed sine in inches.	Radius of beam in Ft. & In.	Length of stroke in Ft. & In.	Versed sine in inches.
4 0	2 0	1½	7 0	4 6	4⅜
... ...	2 3	2	... ...	5 0	5⅝
... ...	2 6	2⅝			
... ...	2 9	2⅞	7 6	3 6	2½
... ...	3 0	3⅛	... ...	4 0	3⅛
			... ...	4 6	4⅛
4 6	2 0	1⅝	... ...	5 0	5
... ...	2 3	1⅞	... ...	5 6	6⅛
... ...	2 6	2⅛			
... ...	2 9	2⅜	8 0	4 0	3
... ...	3 0	3	... ...	4 6	3⅝
... ...	3 6	4⅛	... ...	5 0	4⅜
			... ...	5 6	5⅛
5 0	2 6	1⅞			
... ...	2 9	2⅛	8 6	4 0	2⅞
... ...	3 0	2⅜	... ...	4 6	3⅜
... ...	3 6	3⅜	... ...	5 0	4⅛
... ...	3 9	4¼	... ...	5 6	5⅜
5 6	2 6	1¾	9 0	4 6	3⅛
... ...	2 9	2	... ...	5 0	4¼
... ...	3 0	2⅛	... ...	5 6	5⅛
... ...	3 6	3⅛	... ...	6 0	6
... ...	4 0	4⅛			
			9 6	5 0	4
6 0	3 0	2¼	... ...	5 6	4⅝
... ...	3 6	3	... ...	6 0	5⅜
... ...	4 0	4			
... ...	4 6	5	10 0	5 0	3¾
			... ...	5 6	4⅛
6 6	3 0	2⅛	... ...	6 0	5⅛
... ...	3 6	2⅝			
... ...	4 0	3⅜	11 0	5 6	4⅛
... ...	4 6	4⅛	... ...	6 0	5
... ...	5 0	5¼	... ...	6 6	5¾
7 0	3 6	2⅝	12 0	6 0	4½
... ...	4 0	3½	... ...	6 6	5⅛
			... ...	7 0	6⅛

THE FLY WHEEL.

Fly wheels, in general, are for the purpose of equalizing motion; but in a steam-engine the fly wheel is also the means by which uniform circular motion is obtained from alternate rectilinear motion; and, to produce a proper effect, require a certain momentum, or a certain weight in motion, at a certain velocity; hence the following rule, deduced from practice, gives the weight of the wheel in all ordinary cases:—

RULE.—Divide 1400 times the number of horses' power the engine is equal to by the diameter of the wheel in feet, multiplied by the number of revolutions per minute, and the quotient is the weight of the ring or rim of the wheel, in cwts.

EXAMPLE.—Required the necessary weight for the ring or rim of a fly wheel for a thirty horse engine, making 18 revolutions per minute, the wheel to be 25 feet diameter.

$$\frac{1400 \times 30}{25 \times 18} = 93.3 \text{ cwts.}$$

To determine the dimensions of the ring, suitable to a given weight in cast iron.

RULE 1.—Make the breadth in inches about equal to the square root of the weight in cwts.

2.—Add together the inside and outside diameters of the ring in inches, multiply the sum by their difference, and by .2065 for a divisor, by which divide the required weight in lbs., and the quotient is the thickness of the *ring in inches*. Thus,—Suppose the weight and dia-

meter of the wheel, as above; required the breadth and thickness.

$\sqrt{93.3} = 9.7$ inches, breadth of ring, or say $9\frac{1}{2}$,

Then, $25 \times 12 = 300$ inches, and

$93.3 \times 112 = 10449.6$ lbs.

$300 - 19 = 281$, or inside diameter,

$300 + 281 \times 19 \times .2065 = 2279.6$,

And, $\frac{10449.6}{2279.6} = 4.5$ inches in thickness.

Or, if the ring be required of a cylindrical form, multiply the square root of the cross sectional area by 1.12837, and the product is the diameter. Hence,

$\sqrt{9.5 \times 4.5} \times 1.12837 = 7.38$ inches diameter.

When a fly wheel of a known weight, at a given velocity, is required, to find the weight required at any other velocity,—or, the velocity required at any given weight.

RULE.—Multiply the weight required by its given velocity, and divide by the proposed velocity, the quotient is the weight required. Or, divide by the weight and the quotient equal the velocity.

EXAMPLE 1.—Suppose the required weight of a fly wheel for an engine be 65 cwt., at 20 revolutions per minute, what weight will it require to be when the velocity is increased to 30 revolutions per minute?

$\frac{65 \times 20}{30} = 43.3$ cwt. for the weight of the ring.

2. Let the weight of a fly wheel be 43.3 cwt., with a velocity of 20 revolutions per minute, required the increased velocity, so that the momentum may equal 65 cwt.

$\frac{65 \times 20}{43.3} = 30$ revolutions per minute.

FLY WHEEL SHAFT, PADDLE SHAFTS, &c.

In speaking of shafts, it is the journals, or bearings of the shaft that must be understood; and according to the different materials of which they are formed, or the different purposes to which they are applied, so do they require to be of different dimensions; hence the following proportions are the result of our present practice:

Multipliers
- 450 for cast-iron shafts in land or stationary engines,
- 356 for wrought-iron paddle shafts for sea-going vessels,
- 194 for wrought-iron paddle shafts for small river packets, &c.

General Rule.—Multiply the number of horses' power by the multiplier opposite the purpose to which it is to be employed, divide the product by the number of revolutions per minute, and the cube root of the quotient is the shaft's diameter in inches.

Example.—Required the diameter of a wrought-iron paddle shaft for an engine of 40 horse power, making 25 revolutions per minute.

$$\sqrt[3]{\frac{356 \times 40}{25}} = 8.28 \text{ inches diameter.}$$

Locomotive crank axles for 12 inch cylinders have bearings about 5 inches diameter, and fore axles $4\frac{1}{4}$ in. diameter; hence, $5^3 \div 12^2 = .86$, and $4.25^3 \div 12^2 = .53$, by which the diameters of other axles may be found in the same proportion, when the diameter of the cylinders are given.

Rule.—Multiply the square of the cylinder's dia-

meter in inches by .86 for crank axles, or .53 for fore axles, and the cube root of the product equal the diameter in inches.

EXAMPLE.—Let the diameter of the cylinders of a locomotive engine equal 14 inches; required the diameters of the bearings for the crank and fore axles.

$\sqrt[3]{14^2 \times .86} = 5.52$ inches, diameter of the crank axle,

And $\sqrt[3]{14^2 \times .53} = 4.69$ inches, diameter of the fore axle.

THE GOVERNOR, OR REGULATOR,

Is a necessary appendage attached to land or stationary engines, for the purpose of regulating the quantity of steam according to the quantity of work, and thereby causing a uniformity of motion, which otherwise would not be the case.

Governors are variously constructed, to suit the different situations in which they require to be placed, but their general principle is the same, and consists of a double pendulum attached to, and made to revolve round on a spindle by the power of the engine; consequently, the pendulums ought to be of a certain length to correspond to a given velocity,—or, the velocity made to correspond with pendulums of a given length. Hence, according to the nature of a pendulum, the square root of its length multiplied by the number of vibrations in a given time equal a number by which the length and number of vibrations of other pendulums are regulated; thus, a pendulum that will vibrate seconds, or 60 in the latitude of London, is 39.1393 inches long; and $\sqrt{39.1393} \times 60 = 375.36$, or, for the purposes of a governor, 375; and hence,

RULE 1.—Divide 375 by the square root of the pendulum's length, and the quotient equal the vibrations per minute, or half the quotient equal the number of revolutions in the same time.

2.—Divide 375 by twice the number of revolutions per minute, and the square of the quotient equal the pendulum's length in inches.

EXAMPLE 1.—Required the number of revolutions per minute for a governor with pendulums 30 inches in length.

$$\frac{375}{\sqrt{30}} = 68.5 \div 2 = 34.25 \text{ revolutions per minute.}$$

Ex. 2.—Required the length of pendulums for a governor to make 47 revolutions per minute.

$$\frac{375}{47 \times 2} = 3.99^2 = 15.92 \text{ inches in length.}$$

The motion of a governor is generally derived from the fly wheel shaft of an engine, and communicated by means of pulleys, wheels, &c.; therefore, *to find the diameter of a pulley, or number of teeth in a wheel to produce any required velocity*, observe the following

RULE.—Multiply the diameter of the pulley, or number of teeth in the wheel on the governor spindle, by the velocity of the governor, or number of revolutions per minute, and divide by the velocity or number of revolutions of the engine in the same time; the quotient is the pulley's diameter, or number of teeth in the wheel on the fly wheel shaft. Or, Multiply the velocity of the engine per minute by the diameter of the pulley, or number of teeth in the wheel on the fly wheel shaft, and divide by the required velocity of the governor; the quotient is the pulley's diameter, or number of teeth in the wheel on the governor spindle.

EXAMPLE 1.—Required the diameter of a pulley for

the spindle of a governor, so that it may perform 36 revolutions per minute; velocity of the engine 22, and the pulley on the fly wheel shaft 18 inches diameter.

$$\frac{22 \times 18}{36} = 11 \text{ inches diameter.}$$

Ex. 2.—Suppose an engine and governor situated as follows:—

Velocity of the engine 34 revolutions per minute,
Velocity of the governor 52 revolutions per minute,
Diameter of pulley on fly wheel shaft 16 inches,
Diameter of pulley on intermediate shaft 12 inches,
Wheel on governor spindle 40 teeth;

Required the number of teeth in the wheel on the intermediate shaft.

$$\frac{52 \times 40 \times 12}{34 \times 16} = 46 \text{ teeth.}$$

Ex. 3.—Again, suppose the engine and governor situated as above, required the diameter of the pulley on the intermediate spindle.

$$\frac{34 \times 16 \times 46}{52 \times 40} = 12 \text{ inches diameter.}$$

NOTE.—The weight of the balls in lbs. ought to be about $1\frac{1}{4}$ times the length of the pendulums in inches, and the levers to the throttle valve ought to be so adjusted that the greatest angle of the pendulums with the spindle may not exceed about 45 degrees.

A SUMMARY OF MISCELLANEOUS REMARKS, TABLES, AND PROPORTIONS.

Proportionate power for steam-packets.—The power of an engine or engines for a steam-packet on a river, lake, &c., ought to be equal to 1 horse for every 2 tons, builders' measurement. Coasting packets, having an average run of 250 to 300 miles, 1 horse power to every $2\frac{1}{2}$ tons. And sea-going packets, whose average runs are from 700 to 1000 miles, 1 horse power to every $3\frac{1}{2}$ tons.

Power for steam-packets with increased velocity.—The power requisite to propel a packet or vessel of any description, at a given increase of velocity, is as the cube of the one velocity is to the cube of the other. Hence, suppose a power of 50 horses is required to propel a vessel at the rate of 8 miles per hour, what must be the power so as to propel the same at the rate of 10 miles per hour?

$$\frac{10^3 \times 50}{8^3} = \frac{50000}{512} = 97.6 \text{ horses' power.}$$

Paddle wheels.—The proportionate diameter of paddle wheels is, for river packets, &c. about $7\frac{1}{2}$ times the length of the crank. For coasting and sea-going vessels 8 to $8\frac{1}{2}$ times the length of the crank; and in either case the surface of the paddle boards calculated according to the rule given at page 40. Distance between each board, at the extreme diameter of the wheel, about $3\frac{1}{2}$ feet.

Paddle shafts.—A common rule for the diameters of the bearings of wrought iron paddle shafts is,—

For river packets—inside bearings $\frac{1}{6}$, outside bearings $\frac{1}{8}$.
And other packets ,, $\frac{1}{5}$,, $\frac{1}{7}$.
of the cylinder's diameter.

Piston rods.—Diameter of piston rods for land engines with long strokes, and marine engines for sea-going vessels, $\frac{1}{10}$th of the cylinder's diameter. For land engines with short strokes, and river packet engines, $\frac{1}{12}$th. Locomotive engines, $\frac{1}{7}$th.

Air pump rods.—Diameter of air pump rods, $\frac{1}{10}$th of the pump's diameter; if copper, $\frac{1}{8}$th.

Length of stroke.—Proportionate length of stroke for condensing engines, twice the cylinder's diameter; non-condensing, three times.

Injection cocks.—Area of injection cocks about .4 of an inch to each horse power. Or, make the diameter of the cock $\frac{1}{15}$th of the cylinder's diameter.

Chimneys.—Diameter of steam-packet and locomotive chimneys equal the diameter of the cylinder. In vessels with only one engine, $\frac{2}{3}$rds the cylinder's diameter.

Fuel.—In the consumption of fuel in steam-engines much depends upon the quality of the fuel, as regards the quantity expended, and effect produced. Coal varies from 8 to 13 lbs. in evaporating one cubic foot of water, but a greater body of fire will evaporate a greater quantity of water with a less proportion of fuel; hence, *large* engines require less fuel in proportion to their power than *small* ones.

Proportionate consumption of fuel.—It is ascertained from practice that steam at 3 lbs. per square inch, and produced from water of an average quality, requires to be maintained with about $13\frac{1}{2}$ lbs. of good coal per hour for each horse power, when the lap or cover of the valve is $\frac{1}{4}$th the width of the opening to the cylinder.

Steam at $4\frac{1}{2}$ lbs. per square inch requires 11lbs. of coal, when the cover of the valve is $\frac{1}{3}$rd; and, Steam at 6 lbs. requires 8 lbs. of coal, when the cover of the valve is $\frac{1}{2}$ the width of the opening to the cylinder.

Comparative consumption of fuel.—To convert 1 cubic foot of water, of an average quality, at 52° Ft., to steam at 220°, requires

Of Newcastle, or caking coal, about	8.4	lbs. avd.
Splint coal	8.4	,,
Staffordshire cherry coal	11.2	,,
Pine wood	19.2	,,
Charcoal	10.6	,,
Coke	7.7	,,

Boiling points of water.—Boiling point of pure water under common atmospheric pressure .....212° Ft.

Sea water				213.2
Water holding in solution	$\frac{2}{33}$	parts	salt,	214.4
,, ,,	$\frac{6}{33}$	,,		219
Saturated water	$\frac{12}{33}$	,,		226

To find the quantity of water at a given temperature, necessary to reduce steam at a given temperature to water of a given temperature.

Rule.—To 1000°, or the latent heat of steam, add the given temperature of the steam minus the required temperature of the water after condensation; divide the product by the required temperature of the water, minus the temperature of the water by which the steam is to be reduced, and the quotient is the excess of water over that by which the steam was produced.

Example.—Let it be required to reduce steam at 220° to water at 100°, by water at 52°, required the quantity.

$$\frac{1000 + 220 - 100}{100 - 52} = 23.3$$ times the quantity of water to that of which the steam was produced.

Or, suppose steam at 220° to be reduced to water of 180° by water at 52°, required the quantity.

$$\frac{1000 + 220 - 80}{180 - 52} = 8$$ times the quantity.

The following is a summary of experiments on the Grand Junction Railway, for the purpose of ascertaining the quantity of coke consumed to the quantity of load transported.

Names of engines.	Date of experiment, 1838.	LOAD.			RATE OF TRAVELLING.			COKE CONSUMED.				WATER EVAPORATED.		
		Carriage, &c.	Engine and tender.	Gross load.	Total distance run.	Time.	Mean rate.	Total quantity in	Per mile.	Per ton per mile. Goods.	Per ton per mile. Gross load.	During the trip.	Cubic feet.	Lbs. of coke.
		Tons.	Tons.	Tons.	Miles.	Hr. Mt.	Miles per hour	Lbs.	Lbs.	Lbs.	Lbs.	Imperial gallons.	Per hour.	Per cubic ft
Phalaris ...	May 30 ..... 31 June 1 July 5	39.2	20	59.2	778	33 46	23.05	26812	37.03	.95	.62	17230	81.9	10.43
Prometheus	June 5 ..... 6 ..... 7 8	36.7	20	56.7	778	34 33	22.53	26715	34.3	.93	.60	17610	81.7	9.39
Prometheus	June 11 ..... 12 13	32.8	20	52.8	583.5	26 6	22.38	24493	41.9	1.28	.79	12740	78.2	11.97
Phalaris ...	June 14 ..... 15 16	42.6	20	62.6	583.5	26 28	22.08	22486	38.5	.90	.61	11450	67.6	12.24
Prometheus	June 22 ..... 23 ..... 25 26	41.1	20	61.1	778	36 5	21.49	36686	47.1	1.14	.77	19050	84.6	11.98
Phalaris ...	July 2 ..... 3 4	34.46	20	54.46	583.5	24 42	23.62	20652	35.4	1.03	.65	12360	80.3	10.49

Table of experiments on the London and Birmingham Railway.

Description of the engines.	LOAD.			VELOCITY.			COKE CONSUMED.			WATER EVAPORATED.		
	Carriages, Passengers, &c.	Engine and tender.	Gross load in	Rate at full speed in miles per hour.	Pressure of steam per square inch.	Mean rate of speed in miles per hour.	During the trip.	Per ton per mile.	Per mile. Gross	During the trip.	Cubic feet per hour.	Pounds of coke per cub. foot.
	Tons.	Tons.	Tons.	Miles.	Lbs.	Miles.	Lbs.	Goods.	Load.	Galls.	Feet.	Lbs.
12 inch cylinders, and 5 feet wheels...	32.65	17.5	50.15	32.88	53	30.51	434	.89lb	.47lb	300	83.81	8.85
	53.45	17.5	70.95	32.4	53	28.53	601	.59	.4	506	105.9	7.59
	64.36	17.25	81.61	25.53	53	21.85	391	.504	.35	317	70.66	7.62
12 inch cylinders, and 5 feet wheels...	34.45	16.32	50.77	32.41	53.5	31.29	606	1.01	.55	420	91.	8.9
	53.91	15.85	69.76	32.04	53.5	29,32	590	.58	.41	405	94.42	8.13
	67.2	16.33	83.53	23.81	53.5	19,42	1220	.36	.29	935	56,81	8.11

Experiments on the Liverpool and Manchester Railway.—Similar experiments were also made upon the Liverpool and Manchester Railway, by which it was ascertained that an engine having 12 inch cylinders, 16 inch stroke, and 5 feet wheels, surface exposed to the action of the fire, or radiating caloric, 57 square feet, and tube surface, or communicative caloric, 218 square feet, average evaporating power per hour 45 cubic feet, with an average effective pressure of 54 lbs. per square inch, and drawing a load of 190 tons, consumed, of good coke, during the trip of 29½ miles, 1596 lbs., or 28 lbs. per ton per mile on a level; And also the same engine, running the same distance with 25 tons, under as favourable circumstances, consumed 720 lbs., or .82 lbs. per ton per mile. Hence it appears, that the nearer the load approaches to the calculated power of the engine, the less the quantity of fuel expended in proportion to the weight of the load.

Again, the first trip was performed in 3 hours and 2 minutes, and the second in 1 hour and 26 minutes, therefore, about *eight* times the load required only about *twice* the quantity of coke, and the journey performed in little more than *twice* the time.

Distribution of weight in locomotive engines.—The weight of a locomotive engine ought to be so distributed that about $\frac{2}{3}$rds of the whole weight may rest upon the crank axle. When so proportioned, with coupled wheels and the rails dry and clean, the force of adhesion equals at least 45 times the weight upon the crank axle. Thus, suppose an engine of 8 tons,

$$\frac{8 \times 2}{3} = 5.33 \text{ tons upon the crank axle.}$$

And $5.33 \times 45 = 239.85$ tons, or the force of adhesion upon the rails.

Table of railway gradients, or inclined planes.

1 ft. per mile	= 1 in 5280	or .15 of an inch per chain.
1½	= 1 .. 3520	.. .22
2	= 1 .. 2640	.. .30
2½	= 1 .. 2112	.. .37
3	= 1 .. 1760	.. .45
3½	= 1 .. 1508	.. .52
4	= 1 .. 1320	.. .60
4½	= 1 .. 1120	.. .70
5	= 1 .. 1056	.. .75
5½	= 1 .. 966	.. .82
6	= 1 .. 880	.. .90
6½	= 1 .. 812	.. .97
7	= 1 .. 754.2	.. 1.05
7½	= 1 .. 704.0	.. 1.12
8	= 1 .. 660.0	.. 1.20
8½	= 1 .. 621.1	.. 1.27
9	= 1 .. 586 6	.. 1.35
9½	= 1 .. 556 8	.. 1.42
10	= 1 .. 528.0	.. 1.50
10½	= 1 .. 502.8	.. 1.57
11	= 1 .. 480.0	.. 1.65
11½	= 1 .. 459 1	.. 1.72
12	= 1 .. 440.0	.. 1.80
12½	= 1 .. 422.4	.. 1.85
13	= 1 .. 406.1	.. 1.95
13½	= 1 .. 391.1	.. 2.02
14	= 1 .. 377.1	.. 2.10
14½	= 1 .. 364.1	.. 2.17
15	= 1 .. 352.0	.. 2.25
15½	= 1 .. 340.6	.. 2.32
16	= 1 .. 330.0	.. 2.40
16½	= 1 .. 320.0	.. 2.47
17	= 1 .. 310.6	.. 2.55
17½	= 1 .. 301.7	.. 2.63
18	= 1 .. 293.3	.. 2.70
18½	= 1 .. 285.9	.. 2.77
19	= 1 .. 277.9	.. 2.85
19½	= 1 .. 270.7	.. 2.92
20	= 1 .. 264.0	.. 3.00
20½	= 1 .. 257.5	.. 3.07
21	= 1 .. 251.4	.. 3.15
21½	= 1 .. 245.5	.. 3.22
22	= 1 .. 240.0	.. 3.30
22½	= 1 .. 234.6	.. 3.37
23	= 1 .. 229.5	.. 3.45
23½	= 1 .. 224.4	.. 3.52
24	= 1 .. 220.0	.. 3.60
24½	= 1 .. 215.5	.. 3.67
25	= 1 .. 211.2	.. 3.75
25½	= 1 .. 207.3	.. 3.82
26	= 1 .. 203.1	.. 3.90
26½	= 1 .. 199.2	.. 3.97
27	= 1 .. 195.5	.. 4.05
27½	= 1 .. 192.0	.. 4.12
28	= 1 .. 188.6	.. 4.20
28½	= 1 .. 185.6	.. 4.26
29	= 1 .. 182.1	.. 4.35
29½	= 1 .. 178.9	.. 4.42
30	= 1 .. 176.0	.. 4.50
30½	= 1 .. 173.1	.. 4.57
31	= 1 .. 170.3	.. 4.65

Table of railway gradients, or inclined planes.

(CONTINUED.)

31½	ft. per mile	= 1 in	167.6	or 4.72	of an inch per chain.
32	.....	= 1 ..	165.0	.. 4.80	.....
32½	.....	= 1 ..	162.4	.. 4.87	.....
33	.....	= 1 ..	160.0	.. 4.95	.....
33½	.....	= 1 ..	157.6	.. 5.02	.....
34	.....	= 1 ..	155.3	.. 5.10	.....
34½	.....	= 1 ..	153.0	.. 5.17	.....
35	.....	= 1 ..	150.8	.. 5.25	.....
35½	.....	= 1 ..	148.7	.. 5.32	.....
36	.....	= 1 ..	146.6	.. 5 40	.....
36½	.....	= 1 ..	144.9	.. 5.46	.....
37	.....	= 1 ..	142.7	.. 5.55	.....
37½	.....	= 1 ..	140.8	.. 5.62	.....
38	.....	= 1 ..	138.9	.. 5 70	.....
38½	.....	= 1 ..	137.1	.. 5 77	.....
39	.....	= 1 ..	135.4	.. 5 85	.....
39½	.....	= 1 ..	133.6	.. 5.92	.....
40	.....	= 1 ..	132.0	.. 6.00	.....
40½	.....	= 1 ..	130.6	.. 6.06	.....
41	.....	= 1 ..	128.8	.. 6.15	.....
41½	.....	= 1 ..	127.4	.. 6.21	.....
42	.....	= 1 ..	125.7	.. 6.30	.....
42½	.....	= 1 ..	124.2	.. 6.37	.....
43	.....	= 1 ..	122.8	.. 6 45	.....
43½	.....	= 1 ..	121.3	.. 6.52	.....
44	.....	= 1 ..	120.0	.. 6.60	.....
44½	.....	= 1 ..	118.6	.. 6.69	.....
45	.....	= 1 ..	117.3	.. 6.75	.....
45½	.....	= 1 ..	116.0	.. 6.82	.....
46	.....	= 1 ..	114.8	.. 6.90	.....
46½	.....	= 1 ..	113.5	.. 6.97	.....
47	.....	= 1 ..	112.3	.. 7.05	.....
47½	.....	= 1 ..	111.1	.. 7.12	.....
48	.....	= 1 ..	110.0	.. 7.20	.....
48½	.....	= 1 ..	108.0	.. 7.28	.....
49	.....	= 1 ..	107.7	.. 7.35	.....
49½	.....	= 1 ..	106.6	.. 7.42	.....
50	.....	= 1 ..	105.6	.. 7.50	.....
50½	.....	= 1 ..	104.5	.. 7 57	.....
51	.....	= 1 ..	103 5	.. 7 65	.....
51½	.....	= 1 ..	102.5	.. 7.72	.....
52	.....	= 1 ..	101.5	.. 7.80	.....
52½	.....	= 1 ..	100.5	.. 7.88	.....
53	.....	= 1 ..	99.6	.. 7.95	.....
53½	.....	= 1 ..	98.6	.. 8.03	.....
54	.....	= 1 ..	97.8	.. 8.10	.....
54½	.....	= 1 ..	97.0	.. 8.16	.....
55	.....	= 1 ..	96.0	.. 8.25	.....
55½	.....	= 1 ..	95.0	.. 8.32	.....
56	.....	= 1 ..	94.3	.. 8.40	.....
56½	.....	= 1 ..	93.4	.. 8.46	.....
57	.....	= 1 ..	92.6	.. 8.55	.....
57½	.....	= 1 ..	91.8	.. 8.62	.....
58	.....	= 1 ..	91.0	.. 8.70	.....
58½	.....	= 1 ..	90.2	.. 8.77	.....
59	.....	= 1 ..	89.5	.. 8 85	.....
59½	.....	= 1 ..	88.7	.. 8.93	.....
60	.....	= 1 ..	88.0	.. 9.00	.....

To find the effect of gravity upon inclined planes, produced upon a load or weight upon a waggon.

RULE.—Divide 1 ton, or 2240 lbs., by the length of the plane to 1, or unity; to the quotient add 9.334 lbs., the resistance or traction of 1 ton upon a level; divide the whole sum by 9.334, or multiply the sum by .1071, and the result is the proportionate resistance, by the effect of gravity to 1 upon the level.

Curves on railways.—The following table contains the rise or elevation that must be given to the outer rail of a curve upon a railway, for waggons with wheels of 3 feet diameter,—width between the rails 4 feet 8½ inches,—play of the wheels between the rails 1 inch,—and the conicleness or inclination of the tire equal ⅐th of the breadth from the flange.

Radius of the curve in feet.	Elevation in inches, the average velocity per hour being		
	10 miles.	20 miles.	30 miles.
250	1.14in.	5.60in.	12.99in.
500	.57	2.83	6.56
1000	.29	1.43	3.30
2000	.15	.71	1.65
3000	.10	.47	1.10
4000	.07	.36	.83
5000	.06	.28	.66

The elevation for any other arrangement may be ascertained by the following practical formula:—

Let D = the diameter of the wheels in feet,
r = the radius of the curve in feet,
e = half the width of the way in feet,
V = the average velocity in feet per second; thus 20 miles per hour = 29.3 feet per second,
g = the accelerating force of gravitation, or 32 feet per second,
a = 7, or the inclination of the tire,
And y = the rise, or elevation of the outward rail over the inward rail, expressed also in feet.

$$\text{Then } y = \frac{e\,V^2}{g\,r}\left\{2 - \frac{a\,D}{2\,(r+e)}\right\} - \frac{e\,D}{r+e}$$

To find the radius of any curve, or portion of a circle.

RULE.—Take any length of a chord or straight line in the curve, and, to the square of half its length, add the square of the versed sine, divide the sum by twice the versed sine, and the quotient is the radius. Thus,

Suppose the length of the chord in a curve equal to 1 chain, or 66 feet, and versed sine $1\frac{1}{2}$ feet; required the radius.

$$\frac{33^2 + 1.5^2}{1.5 \times 2} = 363.75 \text{ feet.}$$

Leveling.—In leveling railways, canals, &c., the level obtained by means of an instrument, or *level*, is only what is called *apparent level*, or a tangent to the earth's circumference. The earth being a sphere, or nearly so, the *true level* is a curve line equally distant from its centre; hence, to obtain the difference between true and apparent level,

Divide the square of any distance on the earth's circumference by the earth's diameter, and the quotient is the difference, in terms of the same denomination.

For example,—The earth's mean diameter equal 7912 miles, or 501,304,320 inches; consequently, the difference of true and apparent level at the distance of 1 mile, or 63,360 inches, will be

$$\frac{63360^2}{501304320} = 7.962, \text{ or very nearly eight inches.}$$

But although this be the exact difference between true and apparent level on the earth's circumference, in leveling to any distance, the point of sight is depressed about one-seventh of the true difference, by the curvature—refraction of the rays of light; consequently, the difference will be $\frac{7.962}{7} = 1.137$ and $7.962 - 1.137 = 6.825$, or what may be termed the *practical* difference between true and apparent level.

Table of difference between true and apparent level.

Distance in yards.	True difference of level in inches.	Practical difference in inches.	Distance in miles.	True difference in feet and inches.	
100	.026	.023	$\frac{1}{16}$	0	$0\frac{1}{2}$
200	.103	.088	$\frac{1}{8}$	0	2
300	.231	.198	$\frac{3}{16}$	0	$4\frac{1}{2}$
400	.411	.353	1	0	8
500	.643	.551	2	2	8
600	.925	.793	3	6	0
700	1.260	1.08	4	10	7
800	1.645	1.41	5	16	7
900	2.081	1.78	6	23	11
1000	2.570	2.20	7	32	6
1100	3.110	2.66	8	42	6
1200	3.701	3.17	9	53	9
1300	4.344	3.72	10	66	4
1400	5.038	4.32	11	80	3
1500	5.784	4.96	12	95	7
1600	6.580	5.64	13	112	2
1700	7.425	6.76	14	130	1

Table of the force and velocity of the wind.

VELOCITY		Force in lbs. avoirdupois per square foot.
In miles per hour.	In feet per second.	
1	1.47	.005
2	2.93	.020
3	4.40	.044
4	5.87	.079
5	7.33	.123
10	14.67	.492
15	22.00	1.107
20	29.34	1.968
25	36.67	3.075
30	44.01	4.429
35	51.34	6.027
40	58.68	7.873
45	66.01	9.963
50	73.35	12.300
60	88.02	17.715
80	117.36	31.490
100	146.70	49.200

See Ante p. 169

Divisions of different Thermometers.—Degrees of heat vary in different countries, according to the different thermometers made use of. Thus, in Britain, *Fahrenheit's* thermometer is the standard of estimation,—in France, *Celsius*, or *Centigrade*,—in Germany, *Reaumur*—and in Russia, that of *De Lisle*; the boiling and freezing points of which differ as follows :—

	FAHRENHEIT.		CENTIG.		REAUM.		DE LISLE.
Boiling point	212°		100°		80°		0°
Freezing point	32		0		0		150
Thus,	90	=	5	=	4	=	$7\frac{1}{2}$

Table of corresponding degrees of temperature of Farenheit, Reaumur, and the Centigrade Scale.

Faht.	Reaum.	Centig.	Faht.	Reaum.	Centig.
214°	80.9°	101.1°	240°	92.4	115.5
216	81.8	102.2	242	93.3	116.6
218	82.7	103.3	244	94.2	117.7
220	83.6	104.4	246	95.1	118.8
222	84.4	105.6	248	96.0	120.0
224	85.3	106.7	250	96.9	121.1
226	86.2	107.8	260	101.3	126.6
228	87.1	108.9	270	105.8	132.2
230	88.0	110.0	280	110.2	137.8
232	88.9	111.1	290	114.7	143.3
234	89.8	112.2	300	119.1	148.9
236	90.7	113.3	320	128.0	160.0
238	91.6	114.4	350	141.3	176.7

NOTE.

Water at 32°	Faht.	0°	Reaum.	1°	Cent.	= in volume	1.00016.
..... 42	.....	5.5	.....	4.4	.....	=	1.
.....212	.....	80	.....	100	.....	=	1.04382.
Water at 212	saturated with salt					=	1.05198.
Air 32	Faht.	0	Reaum.	1	Cent.	=	1.
.....212	.....	80	.....	100	.....	=	1.3750.
.....392	.....	160	.....	200	.....	=	1.7389.
.....572	.....	240	.....	300	.....	=	2.0976.

Properties of various metals.

Names.	Colour.	Specific gravity.	Weight of a lineal foot 1 inch square.	Weight of a lineal foot 1 inch diam.	Melting point, Fahr.	Scale of ductility.	Scale of malleability.	Ratio of hardness.	Cohesive power of an inch square bar.	Bears in lbs. on a square inch without any alteration	Power of conducting heat.	Scale as conductors of electricity.
			Lbs.	Lbs.					Lbs.	Lbs.		
Gold	Pure yellow	19.35	8.40	6.59	5237°	1	1	1.8	30888	.....	10.0	3
Silver	White	10.51	4.54	3.56	4717	2	2	2.4	38257	.....	9.7	2
Iron, cast	Blue gray	7.27	3.12	2.45	17977	4	8	...	18656	15300	.....	...
Iron, wrought		7.63	3.33	2.61	.....	3	5	4.7	93964	17800	3.7	4
Copper	Red	8.90	3.84	3.02	4587	5	3	2.8	61228	10000	8.9	1
Lead	Blue	11.35	4.93	3.87	594	8	6	1.0	2581	1500	1.8	6
Tin	White	7.29	3.16	2.48	442	7	4	1.2	5322	2880	3.0	5
Zinc	Bluish white	7.00	3.05	2.39	700	6	7	1.6	16600	5700	3.6	7
Bismuth	Yellowish white	9.88	4.26	3.34	476	...	...	2.0	3008	.....	.....	...
Antimony	Bluish white	6.70	.....	.....	932	...	...	1.4	1006	.....	.....	...

NOTE.—Water is *decomposed* by iron, tin, or zinc, at a red heat, but any of the other metals will not decompose water at any temperature.

Table of the friction of metals on metals.

Friction or resistance of	without unguents, equal about	of the whole weight or pressure on the surface.
Brass on wrought iron		
Cast iron on cast iron		
Soft steel on wrought iron		
Brass on steel		
Brass on brass		
Cast iron on wrought iron		
Cast iron on soft steel		
Tin on tin		
Soft steel on soft steel		
Cast iron on hard brass		
Wrought iron on wrought iron		
Brass on cast iron		
Tin on wrought iron		
Tin on cast iron		

NOTE.—From 1½ cwt. to upwards of 6 cwt. per square inch the resistance increases in a very considerable ratio, being the greatest with steel on cast iron, and the least with brass on wrought iron.

Properties of the circle, sphere, &c.

The diameter of a circle being		1.
,, circumference	=	3.1416
,, area	=	.7854
,, side of equal square	=	.8862
,, radius being 1, the area	=	3.1416
,, circumference being 1, the side of equal square	=	.2821
The diameter of a sphere being		1.
,, superficies	=	3.1416
,, solidity	=	.5236
,, side of an equal cube	=	.806
,, length of an equal cylinder of the same diameter	=	.6667

Any circle twice the diameter of another contains twice the circumference of the other, and four times the area. Hence, the circumferences of circles are as their diameters, and their areas as the squares of their diameters.

Any sphere or globe, twice the diameter of anothe contains four times the superficies of the other, a eight times the solid content. Hence, the superficies spheres are as the squares, and the solidity as the cub of their diameters.

Various French measures of frequent reference.

A point is equal to.....	.0148025	English inches
A line	.088815	„
A millemetre	.039371	„
A centimetre	.39371	„
An inch, or pouce	1.06578	„
A decimetre.....	3.9371	„
A foot	12.78933	„
A metre	39.371	„ or 3.2809 Engl.
A toise, or fathom	6.394 English feet.	
A league 14591.1	„ or 4863.7 English yar	
A square inch	1.13582 English square inches.	
A cubic inch...	1.21063	„ cubic „
A cubic metre	35.316	„ cubic feet.

TABLES

OF

THE WEIGHT OF METALS;

SQUARE AND CUBE ROOTS OF NUMBERS;

CIRCUMFERENCES AND AREAS OF CIRCLES;

SUPERFICIES AND SOLIDITIES OF SPHERES

&c., &c., &c.

TABLE I,

Containing the weight of square bar iron, from 1 *to* 10 *feet in length, and from* $\frac{1}{4}$ *of an inch to* 6 *inches square.*

Inches square.	LENGTH OF THE BARS IN FEET.									
	1 foot.	2 feet.	3 feet.	4 feet.	5 feet.	6 feet.	7 feet.	8 feet.	9 feet.	10 feet.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
	0.2	0.4	0.6	0.8	1.1	1.3	1.5	1.7	1.9	2.1
	0.5	1.0	1.4	1.9	2.4	2.9	3.3	3.8	4.3	4.8
	0.8	1.7	2.5	3.4	4.2	5.1	5.9	6.8	7.6	8.5
	1.3	2.6	4.0	5.3	6.6	7.9	9.2	10.6	11.9	13.2
	1.9	3.8	5.7	7.6	9.5	11.4	13.3	15.2	17.1	19.0
	2.6	5.2	7.8	10.4	12.9	15.5	18.1	20.7	23.3	25.9
1 *in.*	3.4	6.8	10.1	13.5	16.9	20.3	23.7	27.0	30.4	33.8
1¼	4.3	8.6	12.8	17.1	21.4	25.7	29.9	34.2	38.5	42.8
1½	5.3	10.6	15.8	21.1	26.4	31.7	37.0	42.2	47.5	52.8
1¾	6.4	12.8	19.2	25.6	32.0	38.3	44.7	51.1	57.5	63.9
2	7.6	15.2	22.8	30.4	38.0	45.6	53.2	60.8	68.4	76.0
2¼	8.9	17.9	26.8	35.7	44.6	53.6	62.5	71.4	80.3	89.3
2½	10.4	20.7	31.1	41.4	51.8	62.1	72.5	82.8	93.2	103.5
2¾	11.9	23.8	35.6	47.5	59.4	71.3	83.2	95.1	106.9	118.8
2 *in.*	13.5	27.0	40.6	54.1	67.6	81.1	94.6	108.2	121.7	135.2
2¼	15.3	30.5	45.8	61.1	76.3	91.6	106.8	122.1	137.4	152.6
2½	17.1	34.2	51.3	68.4	85.6	102.7	119.8	136.9	154.0	171.1
2¾	19.1	38.1	57.2	76.3	95.3	114.4	133.5	152.5	171.6	190.7
3	21.1	42.2	63.4	84.5	105.6	126.7	147.8	169.0	190.1	211.2
3¼	23.3	46.6	69.9	93.2	116.5	139.8	163.0	186.3	209.6	232.9
3½	25.6	51.1	76.7	102.2	127.8	153.4	178.9	204.5	230.0	255.6
3¾	27.9	55.9	83.8	111.8	139.7	167.6	195.7	223.5	251.5	279.4
3 *in.*	30.4	60.8	91.2	121.7	152.1	182.5	212.9	243.3	273.7	304.2
3¼	33.0	66.0	99.0	132.0	165.1	198.1	231.1	264.1	297.1	330.1
3½	35.7	71.4	107.1	142.8	178.5	214.2	249.9	285.6	321.3	357.0
3¾	38.5	77.0	115.5	154.0	192.5	231.0	269.5	308.0	346.5	385.0
3½	41.4	82.8	124.2	165.6	207.0	248.4	289.8	331.3	372.7	414.1
3¾	44.4	88.8	133.3	177.7	222.1	266.5	310.9	355.3	399.8	444.2
3¾	47.5	95.1	142.6	190.1	237.7	285.2	332.7	380.3	427.8	475.3
3¾	50.8	101.5	152.3	203.0	253.8	304.5	355.3	406.0	456.8	507.6
4 *in.*	54.1	108.2	162.3	216.3	270.4	324.5	378.6	432.7	486.8	540.8
4¼	57.5	115.0	172.6	230.1	287.6	345.1	402.6	460.1	517.7	575.2
4½	61.1	122.1	183.2	244.2	305.3	366.3	427.4	488.4	549.5	610.6
4¾	64.7	129.4	194.1	258.8	323.5	388.2	452.9	517.6	582.3	647.0
4¾	68.4	136.9	205.3	273.8	342.2	410.7	479.1	547.6	616.0	684.5
4¾	72.3	144.6	216.9	289.2	361.5	433.8	506.1	578.4	650.7	723.1
4¾	76.3	152.5	228.8	305.1	381.3	457.6	533.8	610.1	686.4	762.6
4¾	80.3	160.7	241.0	321.3	401.7	482.0	562.3	642.7	723.0	803.3
5 *in.*	84.5	169.0	253.4	337.9	422.4	506.9	591.4	675.8	760.3	844.8
5¼	93.2	186.3	279.5	372.7	465.8	559.0	652.2	745.3	838.5	931.7
5½	102.2	204.5	306.7	409.0	511.2	613.4	715.7	817.9	920.2	1022.4
5¾	111.8	223.5	335.3	447.0	558.8	670.5	782.3	894.0	1005.8	1117.5
6 *in.*	121.7	243.3	365.0	486.7	608.3	730.0	841.6	973.3	1099.5	1216

TABLE II,

Containing the weight of round bar iron, from 1 *to* 10 *feet in length, and from* $\frac{1}{4}$ *of an inch to* 6 *inches diameter.*

Inches diam.	LENGTH OF THE BARS IN FEET.									
	1 foot.	2 feet.	3 feet.	4 feet.	5 feet.	6 feet.	7 feet.	8 feet.	9 feet.	10 feet.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
$\frac{1}{4}$	0.2	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.5	1.7
$\frac{5}{16}$	0.4	0.7	1.1	1.5	1.9	2.2	2.6	3.0	3.4	3.7
$\frac{3}{8}$	0.7	1.3	2.0	2.7	3.3	4.0	4.6	5.3	6.0	6.6
$\frac{7}{16}$	1.0	2.1	3.1	4.2	5.2	6.3	7.3	8.3	9.4	10.4
$\frac{1}{2}$	1.5	3.0	4.5	6.0	7.5	9.0	10.5	11.9	13.4	14.9
$\frac{9}{16}$	2.0	4.1	6.1	8.1	10.2	12.2	14.2	16.3	18.3	20.3
1 *in.*	2.7	5.3	8.0	10.6	13.3	15.9	18.6	21.2	23.9	26.5
$1\frac{1}{16}$	3.4	6.7	10.1	13.4	16.8	20.2	23.5	26.9	30.2	33.6
$1\frac{1}{8}$	4.2	8.3	12.5	16.7	20.9	25.0	29.2	33.4	37.5	41.7
$1\frac{3}{16}$	5.0	10.0	15.1	20.1	25.1	30.1	35.1	40.2	45.2	50.2
$1\frac{1}{4}$	6.0	11.9	17.9	23.9	29.9	35.8	41.8	47.8	53.7	59.7
$1\frac{5}{16}$	7.0	14.0	21.0	28.0	35.1	42.1	49.1	56.1	63.1	70.1
$1\frac{3}{8}$	8.1	16.3	24.4	32.5	40.6	48.8	56.9	65.0	73.2	81.3
$1\frac{7}{16}$	9.3	18.7	28.0	37.3	46.7	56.0	65.3	74.7	84.0	93.3
2 *in.*	10.6	21.2	31.8	42.5	53.1	63.7	74.3	84.9	95.5	106.2
$2\frac{1}{16}$	12.0	24.0	36.0	48.0	59.9	71.9	83.9	95.9	107.9	119.9
$2\frac{1}{8}$	13.4	26.9	40.3	53.8	67.2	80.6	94.1	107.5	121.0	134.4
$2\frac{3}{16}$	15.0	30.0	44.9	60.0	74.9	89.9	104.8	119.8	134.8	149.8
$2\frac{1}{4}$	16.7	33.4	50.1	66.8	83.4	100.1	116.8	133.5	150.2	166.9
$2\frac{5}{16}$	18.3	36.6	54.9	73.2	91.5	109.8	128.1	146.3	164.6	182.9
$2\frac{3}{8}$	20.1	40.2	60.2	80.3	100.4	120.5	140.5	160.6	180.7	200.8
$2\frac{7}{16}$	21.9	43.9	65.8	87.8	109.7	131.7	153.6	175.6	197.5	219.4
3 *in.*	23.9	47.8	71.7	95.6	119.4	143.3	167.2	191.1	215.0	238.9
$3\frac{1}{16}$	25.9	51.9	77.8	103.7	129.6	155.6	181.5	207.4	233.3	259.3
$3\frac{1}{8}$	28.0	56.1	84.1	112.2	140.2	168.2	196.3	224.3	253.4	280.4
$3\frac{3}{16}$	30.2	60.5	90.7	121.0	151.2	181.4	211.7	241.9	272.2	302.4
$3\frac{1}{4}$	32.5	65.0	97.5	130.0	162.6	195.1	227.6	260.1	292.6	325.1
$3\frac{5}{16}$	34.9	69.8	104.7	139.5	174.4	209.3	244.2	279.1	314.0	348.9
$3\frac{3}{8}$	37.3	74.7	112.0	149.3	186.7	224.0	261.3	298.7	336.0	373.3
$3\frac{7}{16}$	39.9	79.7	119.6	159.5	199.3	239.2	279.0	318.9	358.8	398.6
4 *in.*	42.5	84.9	127.4	169.9	212.3	254.8	297.2	339.7	382.2	424.6
$4\frac{1}{16}$	45.2	90.3	135.5	180.7	225.9	271.0	316.2	361.4	406.6	451.7
$4\frac{1}{8}$	48.0	95.9	143.9	191.8	239.8	287.7	335.7	383.6	431.6	479.5
$4\frac{3}{16}$	50.8	101.6	152.4	203.3	254.1	304.9	355.7	406.5	457.3	508.2
$4\frac{1}{4}$	53.8	107.5	161.3	215.0	268.8	322.6	376.3	430.1	483.8	537.6
$4\frac{5}{16}$	56.8	113.6	170.4	227.2	283.9	340.7	397.5	454.3	511.1	567.9
$4\frac{3}{8}$	60.0	119.8	179.7	239.6	299.5	359.4	419.3	479.2	539.1	599.0
$4\frac{7}{16}$	63.1	126.2	189.3	252.4	315.5	378.6	441.7	504.8	567.8	630.9
5 *in.*	66.8	133.5	200.3	267.0	333.8	400.5	467.3	534.0	600.8	667.5
$5\frac{1}{4}$	73.2	146.3	219.5	292.7	365.9	439.0	512.2	585.4	658.5	731.7
$5\frac{1}{2}$	80.3	160.6	240.9	321.2	401.5	481.8	562.1	642.4	722.7	803.0
$5\frac{3}{4}$	87.8	175.6	263.3	351.1	438.9	526.7	614.4	702.2	790.0	877.8
6 *in.*	95.6	191.1	286.7	382.2	477.8	573.3	668.9	764.4	860.0	955.5

TABLE III,

Containing the weight of flat bar iron, 1 foot in length, of various breadths and thicknesses.

Breadth in inches.	THICKNESS IN PARTS OF AN INCH.									
	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1 inch.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1 *in.*	0.83	1.04	1.25	1.45	1.66	1.87	2.08	2.50	2.91	3.33
1 1/16	0.93	1.17	1.40	1.64	1.87	2.00	2.34	2.81	3.28	3.75
1 1/8	1.04	1.30	1.56	1.82	2.08	2.34	2.60	3.12	3.64	4.16
1 3/16	1.14	1.43	1.71	2.00	2.29	2.57	2.86	3.43	4.01	4.58
1 1/4	1.25	1.56	1.87	2.18	2.50	2.81	3.12	3.75	4.37	5.00
1 5/16	1.35	1.69	2.03	2.36	2.70	3.04	3.38	4.06	4.73	5.41
1 3/8	1.45	1.82	2.18	2.55	2.91	3.28	3.64	4.37	5.10	5.83
1 7/16	1.56	1.95	2.34	2.73	3.12	3.51	3.90	4.68	5.46	6.25
2 *in.*	1.66	2.08	2.50	2.91	3.33	3.75	4.16	5.00	5.83	6.66
2 1/16	1.77	2.21	2.65	3.09	3.54	3.93	4.42	5.31	6.19	7.08
2 1/8	1.87	2.34	2.81	3.28	3.75	4.21	4.68	5.62	6.56	7.50
2 3/16	1.97	2.47	2.96	3.46	3.95	4.45	4.94	5.93	6.92	7.91
2 1/4	2.08	2.60	3.12	3.64	4.16	4.68	5.20	6.25	7.29	8.33
2 5/16	2.18	2.73	3.28	3.82	4.37	4.92	5.46	6.56	7.65	8.75
2 3/8	2.29	2.86	3.43	4.01	4.58	5.15	5.72	6.87	8.02	9.16
2 7/16	2.39	2.99	3.59	4.19	4.79	5.39	5.98	7.18	8.33	9.58
3 *in.*	2.50	3.12	3.75	4.37	5.00	5.62	6.25	7.50	8.75	10.00
3 1/16	2.70	3.38	4.06	4.73	5.41	6.09	6.77	8.12	9.47	10.83
3 1/8	2.91	3.64	4.37	5.10	5.83	6.56	7.29	8.75	10.20	11.66
3 1/4	3.12	3.90	4.68	5.46	6.25	7.03	7.81	9.37	10.93	12.50
4 *in.*	3.33	4.16	5.00	5.83	6.66	7.50	8.33	10.00	11.66	13.33
4 1/16	3.54	4.42	5.31	6.19	7.08	7.96	8.85	10.62	12.39	14.16
4 1/8	3.75	4.68	5.62	6.56	7.50	8.43	9.37	11.25	13.12	15.00
4 1/4	3.95	4.94	5.93	6.92	7.91	8.90	9.89	11.87	13.85	15.83
5 *in.*	4.17	5.20	6.25	7.29	8.33	9.37	10.41	12.50	14.58	16.66
5 1/16	4.37	5.46	6.56	7.65	8.75	9.84	10.93	13.12	15.31	17.50
5 1/8	4.58	5.72	6.87	8.02	9.16	10.31	11.45	13.75	16.04	18.33
5 1/4	4.79	5.98	7.18	8.38	9.58	10.78	11.97	14.37	16.77	19.16
6 *in.*	5.00	6.26	7.50	8 75	10.00	11.25	12.50	15.00	17.50	20.00

NOTE.—The weight of wrought iron being 1.

The weight of cast iron	=	.96
Steel	=	1.03
Copper	=	1.17
Brass	=	1.1
Lead	=	1.48

TABLE IV,

Containing the weight of solid cylinders of cast iron, one foot in length, and from ¾ of an inch to 14 inches diameter.

Diameter in Inches.	*Weight in Lbs.*	*Diameter in Inches.*	*Weight in Lbs.*
¾	1.39	5 *in.*	61.96
⅞	1.88	5⅛	64.66
1 *in.*	2.47	5¼	68.31
1⅛	3.13	5⅜	71.00
1¼	3.87	5½	74.98
1⅜	4.68	5⅝	78.65
1½	5.57	5¾	81.95
1⅝	6.54	5⅞	85.81
1¾	7.59		
1⅞	8.71	6 *in.*	89.23
		6¼	96.82
2 *in.*	9.91	6½	104 72
2⅛	11.19	6¾	112.93
2¼	12.54		
2⅜	13.98	7 *in.*	121.45
2½	15.49	7¼	130.28
2⅝	17.08	7½	139.42
2¾	18.74	7¾	148.87
2⅞	20.48		
		8 *in.*	158.63
3 *in.*	22.35	8¼	168.15
3⅛	24.20	8½	179.08
3¼	26.18	8¾	189.00
3⅜	28.23		
3½	30.36	9 *in.*	200.77
3⅝	32.57	9¼	211.12
3¾	34.85	9½	223.70
3⅞	37.21	9¾	235.31
4 *in.*	39.66	10 *in.*	247.87
4⅛	41.80	10½	273.27
4¼	44.77		
4⅜	47.00	11 *in.*	299.92
4½	50.19	11½	327.81
4⅝	52.71	12 *in.*	356.93
4¾	55.92	13	418.90
4⅞	58.72	14	485.83

NOTE.—The area of a circle in inches, multiplied by the lengtl in inches, and by .263 = the weight in lbs. avoirdupois of cas iron.

TABLE V,

Containing the weight of cast iron pipes, 1 foot in length.

Diam. of bore in inches.	THICKNESS IN INCHES.							
	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1 *in.*	$1\frac{1}{8}$	$1\frac{1}{4}$
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
2 *in.*	8.8	12.3	16.1	20.3	.....	.....	.....	.....
$2\frac{1}{2}$	10.6	14.7	19.2	23.9	.....	.....	.....	.....
3	12.4	17.2	22.2	27.6	33.3	39.3	45.6	.....
$3\frac{1}{2}$	14.2	19.6	25.3	31.3	37.6	44.2	51.1	.....
4	16.1	22.1	28.4	35.0	41.9	49.1	56.6	64.4
$4\frac{1}{2}$	18.0	24.5	31.4	38.7	46.2	54.0	62.1	70.6
5	19.8	27.0	34.5	42.3	50.5	58.9	67.6	76.7
$5\frac{1}{2}$	21.6	29.5	37.6	46.0	54.8	63.8	73.2	82.8
6	23.5	31.9	40.7	49.7	59.1	68.7	78.7	88.8
$6\frac{1}{2}$	25.3	34.4	43.7	53.4	63.4	73.4	84.2	95.1
7	27.2	36.8	46.8	56.8	67.7	78.5	89.7	101.2
$7\frac{1}{2}$	29.0	39.1	49.9	60.7	72.0	83.5	95.3	107.4
8	30.8	41.7	52.9	64.4	76.2	88.4	100.8	113.5
$8\frac{1}{2}$	32.9	44.4	56.2	68.3	80.8	93.5	106.5	119.9
9	34.5	46.6	59.1	71.8	84.8	98.2	111.8	125.8
$9\frac{1}{2}$	36.3	49.1	62.1	75.5	89.1	103.1	117.4	131.9
10	38.2	51.5	65.2	79.2	93.4	108.0	122.8	138.1
$10\frac{1}{2}$	.....	54.0	68.2	82.8	97.7	112.9	128.4	144.2
11	.....	56.4	71.3	86.5	102.0	117.8	133.9	150.3
$11\frac{1}{2}$	.....	58.9	74.3	90.1	106.3	122.7	139.4	156.4
12	.....	61.3	77.4	93.6	110.6	127.6	145.0	162.6
13	.....	.....	82.7	101.2	118.2	137.4	154.1	173.5
14	.....	.....	89.3	108.2	126.5	146.2	165.3	185.2
15	.....	.....	95.2	115.7	135.3	156.2	176.2	198.1
16	.....	.....	.....	123.3	143.1	166.1	187.5	211.3
17	.....	.....	.....	130.2	152.5	178.5	198.2	223.4
18	.....	.....	.....	137.0	161.2	185.3	209.1	235.6
19	.....	.....	.....	.....	169.2	195.7	222.3	247.1
20	.....	.....	.....	.....	178.1	205.2	233.2	259.0
21	.....	.....	.....	.....	.....	214.1	243.5	273.2
22	.....	.....	.....	.....	.....	223.0	254.8	285.4
23	.....	.....	.....	.....	.....	233.4	265.5	298.3
24	.....	.....	.....	.....	.....	245.2	277.5	310.6

TABLE VI,

Containing the weight of cast iron balls, from 3 to 12 inches diameter.

Diameter in inches.	Weight in Lbs.	Diameter in inches.	Weight in Lbs.
3	3.7	7 1/8	58.0
3 1/4	4.7	7 1/4	64.0
3 1/2	5.8	8	70.4
3 3/4	7.2	8 1/4	77.3
4	8.8	8 1/2	84.5
4 1/4	10.5	8 3/4	92.2
4 1/2	12.5	9	100.3
4 3/4	14.7	9 1/4	108.9
5	17.1	9 1/2	118.0
5 1/4	19.9	9 3/4	127.6
5 1/2	22.9	10	137.7
5 3/4	26.1	10 1/4	148.2
6	29.7	10 1/2	159.4
6 1/4	33.6	10 3/4	171.0
6 1/2	37.8	11	183.2
6 3/4	42.3	11 1/2	209.4
7	47.2	12	237.9
7 1/4	52.4		

TABLE VII,

Containing the square and cube roots of all numbers from 1 *to* 1728.

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
1	1.0000	1.0000	46	6.7823	3.5830
2	1.4142	1.2599	47	6.8556	3.6088
3	1.7320	1.4422	48	6.9282	3.6342
4	2.0000	1.5874	49	7.0000	3.6593
5	2.2360	1.7099	50	7.0710	3.6840
6	2.4494	1.8171	51	7.1414	3.7084
7	2.6457	1.9129	52	7.2111	3.7325
8	2.8284	2.0000	53	7.2801	3.7562
9	3.0000	2.0800	54	7.3484	3.7797
10	3.1622	2.1544	55	7.4161	3.8029
11	3.3166	2.2239	56	7.4833	3.8258
12	3.4641	2.2894	57	7.5498	3.8485
13	3.6055	2.3513	58	7.6157	3.8708
14	3.7416	2.4101	59	7.6811	3.8929
15	3.8729	2.4662	60	7.7459	3.9148
16	4.0000	2.5198	61	7.8102	3.9364
17	4.1231	2.5712	62	7.8740	3.9578
18	4.2426	2.6207	63	7.9372	3.9790
19	4.3588	2.6684	64	8.0000	4.0000
20	4.4721	2.7144	65	8.0622	4.0207
21	4.5825	2.7589	66	8.1240	4.0412
22	4.6904	2.8020	67	8.1853	4.0615
23	4.7958	2.8438	68	8.2462	4.0816
24	4.8989	2.8844	69	8.3066	4.1015
25	5.0000	2.9240	70	8.3666	4.1212
26	5.0990	2.9624	71	8.4261	4.1408
27	5.1961	3.0000	72	8.4852	4.1601
28	5.2915	3.0365	73	8.5440	4.1793
29	5.3851	3.0723	74	8.6023	4.1983
30	5.4772	3.1072	75	8.6602	4.2171
31	5.5677	3.1413	76	8.7177	4.2358
32	5.6568	3.1748	77	8.7749	4.2543
33	5.7445	3.2075	78	8.8317	4.2726
34	5.8309	3.2396	79	8.8881	4.2908
35	5.9160	3.2710	80	8.9442	4.3088
36	6.0000	3.3019	81	9.0000	4.3267
37	6.0827	3.3322	82	9.0553	4.3444
38	6.1644	3.3619	83	9.1104	4.3620
39	6.2449	3.3912	84	9.1651	4.3795
40	6.3245	3.4199	85	9.2195	4.3968
41	6.4031	3.4482	86	9.2736	4.4140
42	6.4807	3.4760	87	9.3273	4.4310
43	6.5574	3.5033	88	9.3808	4.4479
44	6.6332	3.5303	89	9.4339	4.4647
45	6.7082	3.5568	90	9.4868	4.4814

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
91	9.5393	4.4979	140	11.8321	5.1924
92	9.5916	4.5143	141	11.8743	5.2048
93	9.6436	4.5306	142	11.9163	5.2171
94	9.6953	4.5468	143	11.9582	5.2293
95	9.7467	4.5629	144	12.0000	5.2414
96	9.7979	4.5788	145	12.0415	5.2535
97	9.8488	4.5947	146	12.0830	5.2656
98	9.8994	4.6104	147	12.1243	5.2776
99	9.9498	4.6260	148	12.1655	5.2895
100	10.0000	4.6415	149	12.2065	5.3014
01	10.0498	4.6570	150	12.2474	5.3132
102	10.0995	4.6723	151	12.2882	5.3250
103	10.1488	4.6875	152	12.3288	5.3368
104	10.1980	4.7026	153	12.3693	5.3484
105	10.2469	4.7176	154	12.4096	5.3601
106	10.2956	4.7326	155	12.4498	5.3716
107	10.3440	4.7474	156	12.4899	5.3832
108	10.3923	4.7622	157	12.5299	5.3946
109	10.4403	4.7768	158	12.5698	5.4061
110	10.4880	4.7914	159	12.6095	5.4175
111	10.5356	4.8058	160	12.6491	5.4288
112	10.5830	4.8202	161	12.6885	5.4401
113	10.6301	4.8345	162	12.7279	5.4513
114	10.6770	4.8488	163	12.7671	5.4625
115	10.7238	4.8629	164	12.8062	5.4737
116	10.7703	4.8769	165	12.8452	5.4848
117	10.8166	4.8909	166	12.8840	5.4958
118	10.8627	4.9048	167	12.9228	5.5068
119	10.9087	4.9186	168	12.9614	5.5178
120	10.9544	4.9324	169	13.0000	5.5287
121	11.0000	4.9460	170	13.0384	5.5396
122	11.0453	4.9596	171	13.0766	5.5504
123	11.0905	4.9731	172	13.1148	5.5612
124	11.1355	4.9866	173	13.1529	5.5720
125	11.1803	5.0000	174	13.1909	5.5827
126	11.2249	5.0132	175	13.2287	5.5934
127	11.2694	5.0265	176	13.2664	5.6040
128	11.3137	5.0396	177	13.3041	5.6146
129	11.3578	5.0527	178	13.3416	5.6252
130	11.4017	5.0657	179	13.3790	5.6357
131	11.4455	5.0787	180	13.4164	5.6462
132	11.4891	5.0916	181	13.4536	5.6566
133	11.5325	5.1044	182	13.4907	5.6670
134	11.5758	5.1172	183	13.5277	5.6774
135	11.6189	5.1299	184	13.5646	5.6877
136	11.6619	5.1425	185	13.6014	5.6980
137	11.7046	5.1551	186	13.6381	5.7082
138	11.7473	5.1676	187	13.6747	5.7184
139	11.7898	5.1801	188	13.7113	5.7286

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
189	13.7477	5.7387	238	15.4272	6.1971
190	13.7840	5.7488	239	15.4596	6.2058
191	13.8202	5.7589	240	15.4919	6.2144
192	13.8564	5.7689	241	15.5241	6.2230
193	13.8924	5.7789	242	15.5563	6.2316
194	13.9283	5.7889	243	15.5884	6.2402
195	13.9642	5.7988	244	15.6204	6.2487
196	14.0000	5.8087	245	15.6524	6.2573
197	14.0356	5.8186	246	15.6843	6.2658
198	14.0712	5.8284	247	15.7162	6.2743
199	14.1067	5.8382	248	15.7480	6.2827
200	14.1421	5.8480	249	15.7797	6.2911
201	14.1774	5.8577	250	15.8113	6.2996
202	14.2126	5.8674	251	15.8429	6.3079
203	14.2478	5.8771	252	15.8745	6.3163
204	14.2828	5.8867	253	15.9059	6.3247
205	14.3178	5.8963	254	15.9373	6.3330
206	14.3527	5.9059	255	15.9687	6.3413
207	14.3874	5.9154	256	16.0000	6.3496
208	14.4222	5.9249	257	16.0312	6.3578
209	14.4568	5.9344	258	16.0623	6.3660
210	14.4913	5.9439	259	16.0934	6.3742
211	14.5258	5.9533	260	16.1245	6.3825
212	14.5602	5.9627	261	16.1554	6.3906
213	14.5945	5.9720	262	16.1864	6.3988
214	14.6287	5.9814	263	16.2172	6.4069
215	14.6628	5.9907	264	16.2480	6.4150
216	14.6969	6.0000	265	16.2788	6.4231
217	14.7309	6.0092	266	16.3095	6.4312
218	14.7648	6.0184	267	16.3401	6.4392
219	14.7986	6.0276	268	16.3707	6.4473
220	14.8323	6.0368	269	16.4012	6.4553
221	14.8660	6.0459	270	16.4316	6.4633
222	14.8996	6.0550	271	16.4620	6.4712
223	14.9331	6.0641	272	16.4924	6.4792
224	14.9666	6.0731	273	16.5227	6.4871
225	15.0000	6.0822	274	16.5529	6.4950
226	15.0332	6.0911	275	16.5831	6.5029
227	15.0665	6.1001	276	16.6132	6.5108
228	15.0996	6.1091	277	16.6433	6.5186
229	15.1327	6.1180	278	16.6733	6.5265
230	15.1657	6.1269	279	16.7032	6.5343
231	15.1986	6.1357	280	16.7332	6.5421
232	15.2315	6.1446	281	16.7630	6.5499
233	15.2643	6.1534	282	16.7928	6.5576
234	15.2970	6.1622	283	16.8226	6.5654
235	15.3297	6.1710	284	16.8522	6.5731
236	15.3622	6.1797	285	16.8819	6.5808
237	15.3948	6.1884	286	16.9115	6.5885

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
1659	40.7308	11.8381	1694	41.1582	11.9207
1660	40.7430	11.8404	1695	41.1703	11.9231
1661	40.7553	11.8428	1696	41.1825	11.9254
1662	40.7676	11.8452	1697	41.1946	11.9278
1663	40.7798	11.8476	1698	41.2067	11.9301
1664	40.7921	11.8499	1699	41.2189	11.9324
1665	40.8044	11.8523	1700	41.2310	11.9348
1666	40.8166	11.8547	1701	41.2431	11.9371
1667	40.8289	11.8571	1702	41.2553	11.9395
1668	40.8411	11.8594	1703	41.2674	11.9418
1669	40.8533	11.8618	1704	41.2795	11.9441
1670	40.8656	11.8642	1705	41.2916	11.9465
1671	40.8778	11.8665	1706	41.3037	11.9488
1672	40.8900	11.8689	1707	41.3158	11.9511
1673	40.9023	11.8713	1708	41.3279	11.9535
1674	40.9145	11.8736	1709	41.3400	11.9558
1675	40.9267	11.8760	1710	41.3521	11.9581
1676	40.9389	11.8784	1711	41.3642	11.9605
1677	40.9511	11.8807	1712	41.3763	11.9628
1678	40.9633	11.8831	1713	41.3884	11.9651
1679	40.9756	11.8854	1714	41.4004	11.9675
1680	40.9878	11.8878	1715	41.4125	11.9698
1681	41.0000	11.8902	1716	41.4246	11.9721
1682	41.0121	11.8925	1717	41.4366	11.9744
1683	41.0243	11.8949	1718	41.4487	11.9768
1684	41.0365	11.8972	1719	41.4608	11.9791
1685	41.0487	11.8996	1720	41.4728	11.9814
1686	41.0609	11.9019	1721	41.4849	11.9837
1687	41.0731	11.9043	1722	41.4969	11.9860
1688	41.0852	11.9066	1723	41.5090	11.9884
1689	41.0974	11.9090	1724	41.5210	11.9907
1690	41.1096	11.9113	1725	41.5331	11.9930
1691	41.1217	11.9137	1726	41.5451	11.9953
1692	41.1339	11.9160	1727	41.5571	11.9976
1693	41.1460	11.9184	1728	41.5692	12.0000

TABLE VIII,

Containing the circumferences, squares, cubes, and areas of circles, from 1 to 100, advancing by a tenth.

Diam.	Circum.	Square.	Cube.	Area.
1	3.1416	1	1	.7854
.1	3.4557	1.21	1.331	.9503
.2	3.7699	1.44	1.728	1.1309
.3	4.0840	1.69	2.197	1.3273
.4	4.3982	1.96	2.744	1.5393
.5	4.7124	2.25	3.375	1.7671
.6	5.0265	2.56	4.096	2.0106
.7	5.3407	2.89	4.913	2.2698
.8	5.6548	3.24	5.832	2.5446
.9	5.9690	3.61	6.859	2.8352
2	6.2832	4	8	3.1416
.1	6.5973	4.41	9.261	3.4636
.2	6.9115	4.84	10.648	3.8013
.3	7.2256	5.29	12.167	4.1547
.4	7.5398	5.76	13.824	4.5239
.5	7.8540	6.25	15.625	4.9087
.6	8.1681	6.76	17.576	5.3093
.7	8.4823	7.29	19.683	5.7255
.8	8.7964	7.84	21.952	6.1575
.9	9.1106	8.41	24.389	6.6052
3	9.4248	9	27	7.0686
.1	9.7389	9.61	29.791	7.5476
.2	10.0531	10.24	32.768	8.0424
.3	10.3672	10.89	35.937	8.5530
.4	10.6814	11.56	39.304	9.0792
.5	10.9956	12.25	42.875	9.6211
.6	11.3097	12.96	46.656	10.1787
.7	11.6239	13.69	50.653	10.7521
.8	11.9380	14.44	54.872	11.3411
.9	12.2522	15.21	59.319	11.9459
4	12.5664	16	64	12.5664
.1	12.8805	16.81	68.921	13.2025
.2	13.1947	17.64	74.088	13.8544
.3	13.5088	18.49	79.507	14.5220
.4	13.8230	19.36	85.184	15.2053
.5	14.1372	20.25	91.125	15.9043
.6	14.4513	21.16	97.336	16.6190
.7	14.7655	22.09	103.823	17.3494
.8	15.0796	23.04	110.592	18.0956
.9	15.3938	24.01	117.649	18.8574

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
483	21.9772	7.8460	532	23.0651	8.1028
484	22.0000	7.8514	533	23.0867	8.1079
485	22.0227	7.8568	534	23.1084	8.1129
486	22.0454	7.8622	535	23.1300	8.1180
487	22.0680	7.8676	536	23.1516	8.1230
488	22.0907	7.8729	537	23.1732	8.1281
489	22.1133	7.8783	538	23.1948	8.1331
490	22.1359	7.8837	539	23.2163	8.1382
491	22.1585	7.8890	540	23.2379	8.1432
492	22.1810	7.8944	541	23.2594	8.1482
493	22.2036	7.8997	542	23.2808	8.1532
494	22.2261	7.9051	543	23.3023	8.1583
495	22.2485	7.9104	544	23.3238	8.1633
496	22.2710	7.9157	545	23.3452	8.1683
497	22.2934	7.9210	546	23.3666	8.1733
498	22.3159	7.9264	547	23.3880	8.1782
499	22.3383	7.9317	548	23.4093	8.1832
500	22.3606	7.9370	549	23.4307	8.1882
501	22.3830	7.9422	550	23.4520	8.1932
502	22.4053	7.9475	551	23.4733	8.1981
503	22.4276	7.9528	552	23.4946	8.2031
504	22.4499	7.9581	553	23.5159	8.2080
505	22.4722	7.9633	554	23.5372	8.2130
506	22.4944	7.9686	555	23.5584	8.2179
507	22.5166	7.9738	556	23.5796	8.2228
508	22.5388	7.9791	557	23.6008	8.2278
509	22.5610	7.9843	558	23.6220	8.2327
510	22.5831	7.9895	559	23.6431	8.2376
511	22.6053	7.9947	560	23.6643	8.2425
512	22.6274	8.0000	561	23.6854	8.2474
513	22.6495	8.0052	562	23.7065	8.2523
514	22.6715	8.0104	563	23.7276	8.2572
515	22.6936	8.0155	564	23.7486	8.2621
516	22.7156	8.0207	565	23.7697	8.2670
517	22.7376	8.0259	566	23.7907	8.2719
518	22.7596	8.0311	567	23.8117	8.2767
519	22.7815	8.0362	568	23.8327	8.2816
520	22.8035	8.0414	569	23.8537	8.2864
521	22.8254	8.0466	570	23.8746	8.2913
522	22.8473	8.0517	571	23.8956	8.2961
523	22.8691	8.0568	572	23.9165	8.3010
524	22.8910	8.0620	573	23.9374	8.3058
525	22.9128	8.0671	574	23.9582	8.3106
526	22.9346	8.0722	575	23.9791	8.3155
527	22.9564	8.0773	576	24.0000	8.3203
528	22.9782	8.0824	577	24.0208	8.3251
529	23.0000	8.0875	578	24.0416	8.3299
530	23.0217	8.0926	579	24.0624	8.3347
531	23.0434	8.0977	580	24.0831	8.3396

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
581	24.1039	8.3443	630	25.0998	8.5736
582	24.1246	8.3491	631	25.1197	8.5771
583	24.1453	8.3539	632	25.1396	8.5816
584	24.1660	8.3586	633	25.1594	8.5862
585	24.1867	8.3634	634	25.1793	8.5907
586	24.2074	8.3682	635	25.1992	8.5952
587	24.2280	8.3729	636	25.2190	8.5997
588	24.2487	8.3777	637	25.2388	8.6042
589	24.2693	8.3824	638	25.2586	8.6087
590	24.2899	8.3872	639	25.2784	8.6132
591	24.3104	8.3919	640	25.2982	8.6177
592	24.3310	8.3966	641	25.3179	8.6222
593	24.3515	8.4013	642	25.3377	8.6267
594	24.3721	8.4061	643	25.3574	8.6311
595	24.3926	8.4108	644	25.3771	8.6356
596	24.4131	8.4155	645	25.3968	8.6401
597	24.4335	8.4202	646	25.4165	8.6445
598	24.4540	8.4249	647	25.4361	8.6490
599	24.4744	8.4296	648	25.4558	8.6534
600	24.4948	8.4343	649	25.4754	8.6579
601	24.5153	8.4390	650	25.4950	8.6623
602	24.5356	8.4436	651	25.5147	8.6668
603	24.5560	8.4483	652	25.5342	8.6712
604	24.5764	8.4530	653	25.5538	8.6756
605	24.5967	8.4576	654	25.5734	8.6801
606	24.6170	8.4623	655	25.5929	8.6845
607	24.6373	8.4670	656	25.6124	8.6889
608	24.6576	8.4716	657	25.6320	8.6933
609	24.6779	8.4762	658	25.6515	8.6977
610	24.6981	8.4809	659	25.6709	8.7021
611	24.7184	8.4855	660	25.6904	8.7065
612	24.7386	8.4901	661	25.7099	8.7109
613	24.7588	8.4948	662	25.7293	8.7153
614	24.7790	8.4994	663	25.7487	8.7197
615	24.7991	8.5040	664	25.7681	8.7241
616	24.8193	8.5086	665	25.7875	8.7285
617	24.8394	8.5132	666	25.8069	8.7329
618	24.8596	8.5178	667	25.8263	8.7372
619	24.8797	8.5224	668	25.8456	8.7416
620	24.8997	8.5270	669	25.8650	8.7459
621	24.9198	8.5316	670	25.8843	8.7503
622	24.9399	8.5361	671	25.9036	8.7546
623	24.9599	8.5407	672	25.9229	8.7590
624	24.9799	8.5453	673	25.9422	8.7633
625	25.0000	8.5498	674	25.9615	8.7677
626	25.0199	8.5544	675	25.9807	8.7720
627	25.0399	8.5589	676	26.0000	8.7763
628	25.0599	8.5635	677	26.0192	8.7807
629	25.0798	8.5680	678	26.0384	8.7850

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
679	26.0576	8.7893	728	26.9814	8.9958
680	26.0768	8.7936	729	27.0000	9.0000
681	26.0959	8.7979	730	27.0185	9.0041
682	26.1151	8.8022	731	27.0370	9.0082
683	26.1342	8.8065	732	27.0554	9.0123
684	26.1533	8.8108	733	27.0739	9.0164
685	26.1725	8.8151	734	27.0924	9.0205
686	26.1916	8.8194	735	27.1108	9.0246
687	26.2106	8.8237	736	27.1293	9.0287
688	26.2297	8.8280	737	27.1477	9.0328
689	26.2488	8.8322	738	27.1661	9.0368
690	26.2678	8.8365	739	27.1845	9.0409
691	26.2868	8.8408	740	27.2029	9.0450
692	26.3058	8.8450	741	27.2213	9.0491
693	26.3248	8.8493	742	27.2396	9.0531
694	26.3438	8.8535	743	27.2580	9.0572
695	26.3628	8.8578	744	27.2763	9.0613
696	26.3818	8.8620	745	27.2946	9.0653
697	26.4007	8.8663	746	27.3130	9.0694
698	26.4196	8.8705	747	27.3313	9.0734
699	26.4386	8.8748	748	27.3495	9.0775
700	26.4575	8.8790	749	27.3678	9.0815
701	26.4764	8.8832	750	27.3861	9.0856
702	26.4952	8.8874	751	27.4043	9.0896
703	26.5141	8.8917	752	27.4226	9.0936
704	26.5329	8.8959	753	27.4408	9.0977
705	26.5518	8.9001	754	27.4590	9.1017
706	26.5706	8.9043	755	27.4772	9.1057
707	26.5894	8.9085	756	27.4954	9.1097
708	26.6082	8.9127	757	27.5136	9.1137
709	26.6270	8.9169	758	27.5317	9.1177
710	26.6458	8.9211	759	27.5499	9.1218
711	26.6645	8.9253	760	27.5680	9.1258
712	26 6833	8.9294	761	27.5862	9.1298
713	26.7020	8.9336	762	27.6043	9.1338
714	26.7207	8.9378	763	27.6224	9.1377
715	26 7394	8.9420	764	27.6405	9.1417
716	26.7581	8.9461	765	27.6586	9.1457
717	26.7763	8.9503	766	27.6767	9.1497
718	26.7955	8.9545	767	27.6947	9.1537
719	26.8141	8.9586	768	27.7128	9.1577
720	26.8328	8.9628	769	27.7308	9.1616
721	26.8514	8.9669	770	27.7488	9.1656
722	26 8700	8.9711	771	27.7668	9.1696
723	26.8886	8.9752	772	27.7848	9.1735
724	26.9072	8.9793	773	27.8028	9.1775
725	26.9258	8.9835	774	27.8208	9.1815
726	26.9443	8.9876	775	27.8388	9.1854
727	26.9629	8.9917	776	27.8567	9.1894

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
777	27.8747	9.1933	826	28.7402	9.3826
778	27.8926	9.1972	827	28.7576	9.3864
779	27.9105	9.2012	828	28.7749	9.3902
780	27.9284	9.2051	829	28.7923	9.3940
781	27.9463	9.2090	830	28.8097	9.3977
782	27.9642	9.2130	831	28.8270	9.4015
783	27.9821	9.2169	832	28.8444	9.4053
784	28.0000	9.2208	833	28.8617	9.4091
785	28.0178	9.2247	834	28.8790	9.4128
786	28.0356	9.2287	835	28.8963	9.4166
787	28.0535	9.2326	836	28.9136	9.4203
788	28.0713	9.2365	837	28.9309	9.4241
789	28.0891	9.2404	838	28.9482	9.4278
790	28.1069	9.2443	839	28.9654	9.4316
791	28.1247	9.2482	840	28.9827	9.4353
792	28.1424	9.2521	841	29.0000	9.4391
793	28.1602	9.2560	842	29.0172	9.4428
794	28.1780	9.2599	843	29.0344	9.4466
795	28.1957	9.2637	844	29.0516	9.4503
796	28.2134	9.2676	845	29.0688	9.4540
797	28.2311	9.2715	846	29.0860	9.4577
798	28.2488	9.2754	847	29.1032	9.4615
799	28.2665	9.2793	848	29.1204	9.4652
800	28.2842	9.2831	849	29.1376	9.4689
801	28.3019	9.2870	850	29.1547	9.4726
802	28.3196	9.2909	851	29.1719	9.4761
803	28.3372	9.2947	852	29.1890	9.4801
804	28.3548	9.2986	853	29.2061	9.4838
805	28.3725	9.3024	854	29.2232	9.4875
806	28.3901	9.3063	855	29.2403	9.4912
807	28.4077	9.3101	856	29.2574	9.4949
808	28.4253	9.3140	857	29.2745	9.4986
809	28.4429	9.3178	858	29.2916	9.5023
810	28.4604	9.3216	859	29.3087	9.5059
811	28.4780	9.3255	860	29.3257	9.5096
812	28.4956	9.3293	861	29.3428	9.5133
813	28.5131	9.3331	862	29.3598	9.5170
814	28.5306	9.3370	863	29.3768	9.5207
815	28.5482	9.3408	864	29.3938	9.5244
816	28.5657	9.3446	865	29.4108	9.5280
817	28.5832	9.3484	866	29.4278	9.5317
818	28.6006	9.3522	867	29.4448	9.5354
819	28.6181	9.3560	868	29.4618	9.5390
820	28.6356	9.3599	869	29.4788	9.5427
821	28.6530	9.3637	870	29.4957	9.5464
822	28.6705	9.3675	871	29.5127	9.5500
823	28.6879	9.3713	872	29.5296	9.5537
824	28.7054	9.3750	873	29.5465	9.5573
825	28.7228	9.3788	874	29.5634	9.5610

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
875	29.5803	9.5646	924	30.3973	9.7399
876	29.5972	9.5682	925	30.4138	9.7434
877	29.6141	9.5719	926	30.4302	9.7469
878	29.6310	9.5755	927	30.4466	9.7504
879	29.6479	9.5792	928	30.4630	9.7539
880	29.6647	9.5828	929	30.4795	9.7575
881	29.6816	9.5864	930	30.4959	9.7610
882	29.6984	9.5900	931	30.5122	9.7644
883	29.7153	9.5937	932	30.5286	9.7679
884	29.7321	9.5973	933	30.5450	9.7714
885	29.7489	9.6009	934	30.5614	9.7749
886	29.7657	9.6045	935	30.5777	9.7784
887	29.7825	9.6081	936	30.5941	9.7829
888	29.7993	9.6117	937	30.6104	9.7854
889	29.8161	9.6153	938	30.6267	9.7889
890	29.8328	9.6190	939	30.6431	9.7923
891	29.8496	9.6226	940	30.6594	9.7958
892	29.8663	9.6262	941	30.6757	9.7993
893	29.8831	9.6297	942	30.6920	9.8028
894	29.8998	9.6333	943	30.7083	9.8062
895	29.9165	9.6369	944	30.7245	9.8097
896	29.9332	9.6405	945	30.7408	9.8131
897	29.9499	9.6441	946	30.7571	9.8166
898	29.9666	9.6477	947	30.7733	9.8201
899	29.9833	9.6513	948	30.7896	9.8235
900	30.0000	9.6548	949	30.8058	9.8270
901	30.0166	9.6584	950	30.8220	9.8304
902	30.0333	9.6620	951	30.8382	9.8339
903	30.0499	9.6656	952	30.8544	9.8373
904	30.0665	9.6691	953	30.8706	9.8408
905	30.0832	9.6727	954	30.8868	9.8442
906	30.0998	9.6763	955	30.9030	9.8476
907	30.1164	9.6798	956	30.9192	9.8511
908	30.1330	9.6834	957	30.9354	9.8545
909	30.1496	9.6869	958	30.9515	9.8579
910	30.1662	9.6905	959	30.9677	9.8614
911	30.1827	9.6940	960	30.9838	9.8648
912	30.1993	9.6976	961	31.0000	9.8682
913	30.2158	9.7011	962	31.0161	9.8716
914	30.2324	9.7046	963	31.0322	9.8751
915	30.2489	9.7082	964	31.0483	9.8785
916	30.2654	9.7117	965	31.0644	9.8819
917	30.2820	9.7153	966	31.0805	9.8853
918	30.2985	9.7188	967	31.0966	9.8887
919	30.3150	9.7223	968	31.1126	9.8921
920	30.3315	9.7258	969	31.1287	9.8955
921	30.3479	9.7294	970	31.1448	9.8989
922	30.3644	9.7329	971	31.1608	9.9023
923	30.3809	9.7364	972	31.1769	9.9057

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
973	31.1929	9.9091	1022	31.9687	10.0728
974	31.2089	9.9125	1023	31.9843	10.0760
975	31.2249	9.9159	1024	32.0000	10.0793
976	31.2409	9.9193	1025	32.0156	10.0826
977	31.2569	9.9227	1026	32.0312	10.0859
978	31.2729	9.9261	1027	32.0468	10.0892
979	31.2889	6.9295	1028	32.0624	10.0924
980	31.3049	9.9328	1029	32.0780	10.0957
981	31.3209	9.9362	1030	32.0936	10.0990
982	31.3368	9.9396	1031	32.1091	10.1022
983	31.3528	9.9430	1032	32.1247	10.1055
984	31.3687	9.9463	1033	32.1403	10.1088
985	31.3847	9.9497	1034	32.1558	10.1120
986	31.4006	9.9531	1035	32.1714	10.1153
987	31.4165	9.9564	1036	32.1869	10.1185
988	31.4324	9.9598	1037	32.2024	10.1218
989	31.4483	9.9631	1038	32.2180	10.1250
990	31.4642	9.9665	1039	32.2335	10.1283
991	31.4801	9.9699	1040	32.2490	10.1315
992	31.4960	9.9732	1041	32.2645	10.1348
993	31.5119	9.9766	1042	32.2800	10.1380
994	31.5277	9.9799	1043	32.2955	10.1413
995	31.5436	9.9833	1044	32.3109	10.1445
996	31.5594	9.9866	1045	32.3264	10.1478
997	31.5753	9.9899	1046	32.3419	10.1510
998	31.5911	9.9933	1047	32.3573	10.1542
999	31.6069	9.9966	1048	32.3728	10.1575
1000	31.6227	10.0000	1049	32.3882	10.1607
1001	31.6385	10.0033	1050	32.4037	10.1639
1002	31.6543	10.0066	1051	32.4191	10.1671
1003	31.6701	10.0099	1052	32.4345	10.1704
1004	31.6859	10.0133	1053	32.4499	10.1736
1005	31.7017	10.0166	1054	32.4653	10.1768
1006	31.7175	10.0199	1055	32.4807	10.1800
1007	31.7332	10.0232	1056	32.4961	10.1832
1008	31.7490	10.0265	1057	32.5115	10.1865
1009	31.7647	10.0299	1058	32.5269	10.1897
1010	31.7804	10.0332	1059	32.5422	10.1929
1011	31.7962	10.0365	1060	32.5576	10.1961
1012	31.8119	10.0398	1061	32.5729	10.1993
1013	31.8276	10.0431	1062	32.5883	10.2025
1014	31.8433	10.0464	1063	32.6036	10.2057
1015	31.8590	10.0497	1064	32.6190	10.2089
1016	31.8747	10.0530	1065	32.6343	10.2121
1017	31.8904	10.0563	1066	32.6496	10.2153
1018	31.9061	10.0596	1067	32.6649	10.2185
1019	31.9217	10.0629	1068	32.6802	10.2217
1020	31.9374	10.0662	1069	32.6955	10.2249
1021	31.9530	10.0695	1070	32.7108	10.2280

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1071	32.7261	10.2312	1120	33.4664	10.3849
1072	32.7414	10.2344	1121	33.4813	10.3880
1073	32.7566	10.2376	1122	33.4962	10.3911
1074	32.7719	10.2408	1123	33.5111	10.3942
1075	32.7871	10.2439	1124	33.5261	10.3973
1076	32.8024	10.2471	1125	33.5410	10.4004
1077	32.8176	10.2503	1126	33.5559	10.4034
1078	32.8329	10.2535	1127	33.5708	10.4065
1079	32.8481	10.2566	1128	33.5857	10.4096
1080	32.8633	10.2598	1129	33.6005	10.4127
1081	32.8785	10.2630	1130	33.6154	10.4158
1082	32.8937	10.2661	1131	33.6303	10.4188
1083	32.9089	10.2693	1132	33.6452	10.4219
1084	32.9241	10.2725	1133	33.6600	10.4250
1085	32.9393	10.2756	1134	33.6749	10.4280
1086	32.9545	10.2788	1135	33.6897	10.4311
1087	32.9696	10.2819	1136	33.7045	10.4342
1088	32.9848	10.2851	1137	33.7194	10.4372
1089	33.0000	10.2882	1138	33.7342	10.4403
1090	33.0151	10.2914	1139	33.7490	10.4433
1091	33.0302	10.2945	1140	33.7638	10.4464
1092	33.0454	10.2977	1141	33.7786	10.4494
1093	33.0605	10.3008	1142	33.7934	10.4525
1094	33.0756	10.3039	1143	33.8082	10.4555
1095	33.0907	10.3071	1144	33.8230	10.4586
1096	33.1058	10.3102	1145	33.8378	10.4616
1097	33.1209	10.3134	1146	33.8526	10.4647
1098	33.1360	10.3165	1147	33.8673	10.4677
1099	33.1511	10.3196	1148	33.8821	10.4708
1100	33.1662	10.3228	1149	33.8969	10.4738
1101	33.1813	10.3259	1150	33.9116	10.4768
1102	33.1963	10.3290	1151	33.9263	10.4799
1103	33.2114	10.3321	1152	33.9411	10.4829
1104	33.2264	10.3352	1153	33.9558	10.4859
1105	33.2415	10.3384	1154	33.9705	10.4890
1106	33.2565	10.3415	1155	33.9852	10.4920
1107	33.2716	10.3446	1156	34.0000	10.4950
1108	33.2866	10.3477	1157	34.0147	10.4981
1109	33.3016	10.3508	1158	34.0293	10.5011
1110	33.3166	10.3539	1159	34.0440	10.5041
1111	33.3316	10.3570	1160	34.0587	10.5071
1112	33.3466	10.3602	1161	34.0734	10.5101
1113	33.3616	10.3633	1162	34.0881	10.5132
1114	33.3766	10.3664	1163	34.1027	10.5162
1115	33.3916	10.3695	1164	34.1174	10.5192
1116	33.4065	10.3726	1165	34.1320	10.5222
1117	33.4215	10.3757	1166	34.1467	10.5252
1118	33.4365	10.3788	1167	34.1613	10.5282
1119	33.4514	10.3818	1168	34.1760	10.5312

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1169	34.1906	10.5342	1218	34.8998	10.6794
1170	34.2052	10.5372	1219	34.9141	10.6823
1171	34.2198	10.5402	1220	34.9284	10.6852
1172	34.2344	10.5432	1221	34.9428	10.6882
1173	34.2490	10.5462	1222	34.9571	10.6911
1174	34.2636	10.5492	1223	34.9714	10.6940
1175	34.2782	10.5522	1224	34.9857	10.6969
1176	34.2928	10.5552	1225	35.0000	10.6998
1177	34.3074	10.5582	1226	35.0142	10.7027
1178	34.3220	10.5612	1227	35.0285	10.7056
1179	34.3365	10.5642	1228	35.0428	10.7086
1180	34.3511	10.5672	1229	35.0570	10.7115
1181	34.3656	10.5702	1230	35.0713	10.7144
1182	34.3802	10.5731	1231	35.0856	10.7173
1183	34.3947	10.5761	1232	35.0998	10.7202
1184	34.4093	10.5791	1233	35.1140	10.7231
1185	34.4238	10.5821	1234	35.1283	10.7260
1186	34.4383	10.5850	1235	35.1425	10.7289
1187	34.4528	10.5880	1236	35.1567	10.7318
1188	34.4673	10.5910	1237	35.1710	10.7346
1189	34.4818	10.5940	1238	35.1852	10.7375
1190	34.4963	10.5969	1239	35.1994	10.7404
1191	34.5108	10.5999	1240	35.2136	10.7433
1192	34.5253	10.6029	1241	35.2278	10.7462
1193	34.5398	10.6058	1242	35.2420	10.7491
1194	34.5543	10.6088	1243	35.2562	10.7520
1195	34.5687	10.6118	1244	35.2703	10.7549
1196	34.5832	10.6147	1245	35.2845	10.7577
1197	34.5976	10.6177	1246	35.2987	10.7606
1198	34.6121	10.6206	1247	35.3128	10.7635
1199	34.6265	10.6236	1248	35.3270	10.7664
1200	34.6410	10.6265	1249	35.3411	10.7693
1201	34.6554	10 6295	1250	35.3553	10.7721
1202	34.6698	10.6324	1251	35.3694	10.7750
1203	34.6842	10.6354	1252	35.3836	10.7779
1204	34.6987	10.6383	1253	35.3977	10.7807
1205	34.7131	10.6413	1254	35.4118	10.7836
1206	34.7275	10.6442	1255	35.4259	10.7865
1207	34.7419	10.6472	1256	35.4400	10.7893
1208	34.7562	10.6501	1257	35.4541	10.7922
1209	34.7706	10.6530	1258	35.4682	10.7951
1210	34.7850	10.6560	1259	35.4823	10.7979
1211	34.7994	10.6589	1260	35.4964	10.8008
1212	34.8137	10.6618	1261	35.5105	10.8036
1213	34.8281	10.6648	1262	35.5246	10.8065
1214	34.8425	10.6677	1263	35.5387	10.8093
1215	34.8568	10.6706	1264	35.5527	10.8122
1216	34.8711	10.6736	1265	35.5668	10.8150
1217	34.8855	10.6765	1266	35.5808	10.8179

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1267	35.5949	10.8207	1316	36.2767	10.9585
1268	35.6089	10.8236	1317	36.2904	10.9612
1269	35.6230	10.8264	1318	36.3042	10.9640
1270	35.6370	10.8293	1319	36.3180	10.9668
1271	35.6510	10.8321	1320	36.3318	10.9696
1272	35.6651	10.8350	1321	36.3455	10.9723
1273	35.6791	10.8378	1322	36.3593	10.9751
1274	35.6931	10.8406	1323	36.3730	10.9779
1275	35.7071	10.8435	1324	36.3868	10.9806
1276	35.7211	10.8463	1325	36.4005	10.9834
1277	35.7351	10.8491	1326	36.4142	10.9862
1278	35.7491	10.8520	1327	36.4280	10.9889
1279	35.7631	10.8548	1328	36.4417	10.9917
1280	35.7770	10.8576	1329	36.4554	10.9944
1281	35.7910	10.8604	1330	36.4691	10.9972
1282	35.8050	10.8633	1331	36.4828	11.0000
1283	35.8189	10.8661	1332	36.4965	11.0027
1284	35.8329	10.8689	1333	36.5102	11.0055
1285	35.8468	10.8717	1334	36.5239	11.0082
1286	35.8608	10.8746	1335	36.5376	11.0110
1287	35.8747	10.8774	1336	36.5513	11.0137
1288	35.8887	10.8802	1337	36.5650	11.0165
1289	35.9026	10.8830	1338	36.5786	11.0192
1290	35.9165	10.8858	1339	36.5923	11.0219
1291	35.9304	10.8886	1340	36.6060	11.0247
1292	35.9444	10.8914	1341	36.6196	11.0274
1293	35.9583	10.8943	1342	36.6333	11.0302
1294	35.9722	10.8971	1343	36.6469	11.0329
1295	35.9861	10.8999	1344	36.6606	11.0356
1296	36.0000	10.9027	1345	36.6742	11.0384
1297	36.0138	10.9055	1346	36.6878	11.0411
1298	36.0277	10.9083	1347	36.7014	11.0439
1299	36.0416	10.9111	1348	36.7151	11.0466
1300	36.0555	10.9139	1349	36.7287	11.0493
1301	36.0693	10.9167	1350	36.7423	11.0520
1302	36.0832	10.9195	1351	36.7559	11.0548
1303	36.0970	10.9223	1352	36.7695	11.0575
1304	36.1109	10.9251	1353	36.7831	11.0602
1305	36.1247	10.9279	1354	36.7967	11.0629
1306	36.1386	10.9306	1355	36.8103	11.0657
1307	36.1524	10.9334	1356	36.8239	11.0684
1308	36.1662	10.9362	1357	36.8374	11.0711
1309	36.1801	10.9390	1358	36.8510	11.0738
1310	36.1939	10.9418	1359	36.8646	11.0766
1311	36.2077	10.9446	1360	36.8781	11.0793
1312	36.2215	10.9474	1361	36.8917	11.0820
1313	36.2353	10.9501	1362	36.9052	11.0847
1314	36.2491	10.9529	1363	36.9188	11.0874
1315	36.2629	10.9557	1364	36.9323	11.0901

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1365	36.9459	11.0928	1414	37.6031	11.2240
1366	36.9594	11.0955	1415	37.6164	11.2267
1367	36.9729	11.0982	1416	37.6297	11.2293
1368	36.9864	11.1009	1417	37.6430	11.2319
1369	37.0000	11.1037	1418	37.6563	11.2346
1370	37.0135	11.1064	1419	37.6696	11.2372
1371	37.0270	11.1091	1420	37.6828	11.2399
1372	37.0405	11.1118	1421	37.6961	11.2425
1373	37.0540	11.1145	1422	37.7094	11.2451
1374	37.0675	11.1172	1423	37.7226	11.2478
1375	37.0809	11.1199	1424	37.7359	11.2504
1376	37.0944	11.1225	1425	37.7491	11.2530
1377	37.1079	11.1252	1426	37.7624	11.2557
1378	37.1214	11.1279	1427	37.7756	11.2583
1379	37.1348	11.1306	1428	37.7888	11.2609
1380	37.1483	11.1333	1429	37.8021	11.2636
1381	37.1618	11.1360	1430	37.8153	11.2662
1382	37.1752	11.1387	1431	37.8285	11.2688
1383	37.1887	11.1414	1432	37.8417	11.2714
1384	37.2021	11.1441	1433	37.8549	11.2741
1385	37.2155	11.1467	1434	37.8681	11.2767
1386	37.2290	11.1494	1435	37.8813	11.2793
1387	37.2424	11.1521	1436	37.8945	11.2819
1388	37.2558	11.1548	1437	37.9077	11.2845
1389	37.2692	11.1575	1438	37.9209	11.2872
1390	37.2827	11.1601	1439	37.9341	11.2898
1391	37.2961	11.1628	1440	37.9473	11.2924
1392	37.3095	11.1655	1441	37.9605	11.2950
1393	37.3229	11.1682	1442	37.9736	11.2976
1394	37.3363	11.1708	1443	37.9868	11.3002
1395	37.3496	11.1735	1444	38.0000	11.3028
1396	37.3630	11.1762	1445	38.0131	11.3054
1397	37.3764	11.1788	1446	38.0263	11.3080
1398	37.3898	11.1815	1447	38.0394	11.3107
1399	37.4032	11.1842	1448	38.0525	11.3133
1400	37.4165	11.1868	1449	38.0657	11.3159
1401	37.4299	11.1895	1450	38.0788	11.3185
1402	37.4432	11.1922	1451	38.0919	11.3211
1403	37.4566	11.1948	1452	38.1051	11.3237
1404	37.4699	11.1975	1453	38.1182	11.3263
1405	37.4833	11.2001	1454	38.1313	11.3289
1406	37.4966	11.2028	1455	38.1444	11.3315
1407	37.5099	11.2055	1456	38.1575	11.3341
1408	37.5233	11.2081	1457	38.1706	11.3366
1409	37.5366	11.2108	1458	38.1837	11.3392
1410	37.5499	11.2134	1459	38.1968	11.3418
1411	37.5632	11.2161	1460	38.2099	11.3444
1412	37.5765	11.2187	1461	38.2230	11.3470
1413	37.5898	11.2214	1462	38.2361	11.3496

[illegible] OF NUMBERS.

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1561	39.5094	11.6002	1610	40.1248	11.7203
1562	39.5221	11.6027	1611	40.1372	11.7228
1563	39.5347	11.6052	1612	40.1497	11.7252
1564	39.5474	11.6076	1613	40.1621	11.7276
1565	39.5600	11.6101	1614	40.1746	11.7300
1566	39.5727	11.6126	1615	40.1870	11.7325
1567	39.5853	11.6151	1616	40.1995	11.7349
1568	39.5979	11.6175	1617	40.2119	11.7373
1569	39.6106	11.6200	1618	40.2243	11.7397
1570	39.6232	11.6225	1619	40.2367	11.7421
1571	39.6358	11.6249	1620	40.2492	11.7446
1572	39.6484	11.6274	1621	40.2616	11.7470
1573	39.6610	11.6299	1622	40.2740	11.7494
1574	39.6736	11.6323	1623	40.2864	11.7518
1575	39.6862	11.6348	1624	40.2988	11.7542
1576	39.6988	11.6372	1625	40.3112	11.7566
1577	39.7114	11.6397	1626	40.3236	11.7590
1578	39.7240	11.6422	1627	40.3360	11.7614
1579	39.7366	11.6446	1628	40.3484	11.7639
1580	39.7492	11.6471	1629	40.3608	11.7663
1581	39.7617	11.6495	1630	40.3732	11.7687
1582	39.7743	11.6520	1631	40.3856	11.7711
1583	39.7869	11.6544	1632	40.3980	11.7735
1584	39.7994	11.6569	1633	40.4103	11.7759
1585	39.8120	11.6594	1634	40.4227	11.7783
1586	39.8246	11.6618	1635	40.4351	11.7807
1587	39.8371	11.6643	1636	40.4474	11.7831
1588	39.8497	11.6667	1637	40.4598	11.7855
1589	39.8622	11.6692	1638	40.4722	11.7879
1590	39.8748	11.6716	1639	40.4845	11.7903
1591	39.8873	11.6740	1640	40.4969	11.7927
1592	39.8998	11.6765	1641	40.5092	11.7951
1593	39.9124	11.6789	1642	40.5215	11.7975
1594	39.9249	11.6814	1643	40.5339	11.7999
1595	39.9374	11.6838	1644	40.5462	11.8023
1596	39.9499	11.6863	1645	40.5585	11.8047
1597	39.9624	11.6887	1646	40.5709	11.8071
1598	39.9749	11.6911	1647	40.5832	11.8094
1599	39.9874	11.6936	1648	40.5955	11.8118
1600	40.0000	11.6960	1649	40.6078	11.8142
1601	40.0124	11.6985	1650	40.6201	11.8166
1602	40.0249	11.7009	1651	40.6324	11.8190
1603	40.0374	11.7033	1652	40.6448	11.8214
1604	40.0499	11.7058	1653	40.6571	11.8238
1605	40.0624	11.7082	1654	40.6693	11.8261
1606	40.0749	11.7106	1655	40.6816	11.8285
1607	40.0874	11.7131	1656	40.6939	11.8309
1608	40.0998	11.7155	1657	40.7062	11.8333
1609	40.1123	11.7179	1658	40.7185	11.8357

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
1659	40.7308	11.8381	1694	41.1582	11.9207
1660	40.7430	11.8404	1695	41.1703	11.9231
1661	40.7553	11.8428	1696	41.1825	11.9254
1662	40.7676	11.8452	1697	41.1946	11.9278
1663	40.7798	11.8476	1698	41.2067	11.9301
1664	40.7921	11.8499	1699	41.2189	11.9324
1665	40.8044	11.8523	1700	41.2310	11.9348
1666	40.8166	11.8547	1701	41.2431	11.9371
1667	40.8289	11.8571	1702	41.2553	11.9395
1668	40.8411	11.8594	1703	41.2674	11.9418
1669	40.8533	11.8618	1704	41.2795	11.9441
1670	40.8656	11.8642	1705	41.2916	11.9465
1671	40.8778	11.8665	1706	41.3037	11.9488
1672	40.8900	11.8689	1707	41.3158	11.9511
1673	40.9023	11.8713	1708	41.3279	11.9535
1674	40.9145	11.8736	1709	41.3400	11.9558
1675	40.9267	11.8760	1710	41.3521	11.9581
1676	40.9389	11.8784	1711	41.3642	11.9605
1677	40.9511	11.8807	1712	41.3763	11.9628
1678	40.9633	11.8831	1713	41.3884	11.9651
1679	40.9756	11.8854	1714	41.4004	11.9675
1680	40.9878	11.8878	1715	41.4125	11.9698
1681	41.0000	11.8902	1716	41.4246	11.9721
1682	41.0121	11.8925	1717	41.4366	11.9744
1683	41.0243	11.8949	1718	41.4487	11.9768
1684	41.0365	11.8972	1719	41.4608	11.9791
1685	41.0487	11.8996	1720	41.4728	11.9814
1686	41.0609	11.9019	1721	41.4849	11.9837
1687	41.0731	11.9043	1722	41.4969	11.9860
1688	41.0852	11.9066	1723	41.5090	11.9884
1689	41.0974	11.9090	1724	41.5210	11.9907
1690	41.1096	11.9113	1725	41.5331	11.9930
1691	41.1217	11.9137	1726	41.5451	11.9953
1692	41.1339	11.9160	1727	41.5571	11.9976
1693	41.1460	11.9184	1728	41.5692	12.0000

Diam.	Circum.	Square.	Cube.	Area.
10	31.4160	100	1000	78.5400
.1	31.7301	102.01	1030.301	80.1186
.2	32.0443	104.04	1061.208	81.7130
.3	32.3580	106.09	1092.727	83.3230
.4	32.6726	108.16	1124.864	84.9488
.5	32.9868	110.25	1157.625	86.5903
.6	33.3009	112.36	1191.016	88.2475
.7	33.6151	114.49	1225.043	89.9204
.8	33.9292	116.64	1259.712	91.6090
.9	34.2434	118.81	1295.029	93.3133
11	34.5576	121	1331	95.0334
.1	34.8717	123.21	1367.631	96.7691
.2	35.1859	125.44	1404.928	98.5205
.3	35.5010	127.69	1442.897	100.2877
.4	35.8142	129.96	1481.544	102.0705
.5	36.1284	132.25	1520.875	103.8691
.6	36.4425	134.56	1560.896	105.6834
.7	36.7567	136.89	1601.613	107.5134
.8	37.0708	139.24	1643.032	109.3590
.9	37.3840	141.61	1685.159	111.2204
12	37.6992	144	1728	113.0976
.1	38.0133	146.41	1771.561	114.9904
.2	38.3275	148.84	1815.848	116.8989
.3	38.6416	151.29	1860.867	118.8231
.4	38.9558	153.76	1906.624	120.7631
.5	39.2700	156.25	1953.125	122.7187
.6	39.5841	158.76	2000.376	124.6901
.7	39.8983	161.29	2048.383	126.6771
.8	40.2124	163.84	2097.152	128.6799
.9	40.5266	166.41	2146.689	130.6984
13	40.8408	169	2197	132.7326
.1	41.1549	171.61	2248.091	134.7824
.2	41.4691	174.24	2299.968	136.8480
.3	41.7832	176.89	2352.637	138.9294
.4	42.0974	179.56	2406.104	141.0264
.5	42.4116	182.25	2460.375	143.1391
.6	42.7257	184.96	2515.456	145.2675
.7	43.0399	187.69	2571.353	147.4117
.8	43.3540	190.44	2628.072	149.5715
.9	43.6682	193.21	2685.619	151.7471
14	43.9824	196	2744	153.9384
.1	44.2965	198.81	2803.221	156.1453
.2	44.6107	201.64	2863.288	158.3680
.3	44.9248	204.49	2924.207	160.6064
.4	45.2390	207.36	2985.984	162.8605
.5	45.5532	210.25	3048.625	165.1303
.6	45.8673	213.16	3112.136	167.4158
.7	46.1815	216.09	3176.523	169.7170
.8	46.4956	219.04	3241.792	172.0340
.9	46.8098	222.01	3307.949	174.3666

Diam.	Circum.	Square.	Cube.	Area.
15	47.1240	225.	3375	176.7150
.1	47.4381	228.01	3442.951	179.0790
.2	47.7523	231.04	3511.808	181.4588
.3	48.0664	234.09	3581.577	183.8542
.4	48.3806	237.16	3652.264	186.2654
.5	48.6948	240.25	3723.875	188.6923
.6	49.0089	243.36	3796.416	191.1349
.7	49.3231	246.49	3869.893	193.5932
.8	49.6372	249.64	3944.312	196.0672
.9	49.9514	252.81	4019.679	198.5569
16	50.2656	256	4096	201.0624
.1	50.5797	259.21	4173.281	203.5835
.2	50.8939	262.44	4251.528	206.1203
.3	51.2080	265.69	4330.747	208.6729
.4	51.5224	268.96	4410.944	211.2411
.5	51.8364	272.25	4492.125	213 8251
.6	52.1505	275.56	4574.296	216.4248
.7	52.4647	278.89	4657.463	219.0402
.8	52.7788	282.24	4741.632	221.6712
.9	53.0930	285.61	4826.809	224.3180
17	53.4072	289	4913	226.9806
.1	53.7213	292.41	5000.211	229.6588
.2	54.0355	295.84	5088.448	232.3527
.3	54.3496	299.29	5177.717	235.0623
.4	54.6038	302.76	5268.024	237.7877
.5	54.9780	306.25	5359.375	240.5287
.6	55.2921	309.76	5451.776	243.2855
.7	55.6063	313.29	5545.233	246.0579
.8	55.9204	316.84	5639.752	248.8461
.9	56.2346	320.41	5735.339	251.6500
18	56.5488	324	5832	254.4696
.1	56.8629	327.61	5929.741	257.3048
.2	57.1771	331.24	6028.568	260.1558
.3	57.4912	334.89	6128.487	263.0226
.4	57.8054	338.56	6229.504	265.9050
.5	58.1196	342.25	6331.625	268.8031
.6	58.4337	345.96	6434.856	271.7169
.7	58.7479	349.69	6539.203	274.6465
.8	59.0620	353.44	6644.672	277.5917
.9	59.3762	357.21	6751.269	280.5527
19	59.6904	361	6859	283.5294
.1	60.0045	364.81	6967.871	286.5217
.2	60.3187	368.64	7077.888	289.5298
.3	60.6328	372.49	7189.057	292.5536
.4	60.9470	376.36	7301.384	295.5931
.5	61.2612	380.25	7414.875	298.6483
.6	61.5753	384.16	7529.536	301.7192
.7	61.8895	388.09	7645.373	304.8060
.8	62.2036	392.04	7762.392	307.9082
.9	62.5178	396.01	7880.599	311.0252

Diam.	Circum.	Square.	Cube.	Area.
10	31.4160	100	1000	78.5400
.1	31.7301	102.01	1030.301	80.1186
.2	32.0443	104.04	1061.208	81.7130
.3	32.3580	106.09	1092.727	83.3230
.4	32.6726	108.16	1124.864	84.9488
.5	32.9868	110.25	1157.625	86.5903
.6	33.3009	112.36	1191.016	88.2475
.7	33.6151	114.49	1225.043	89.9204
.8	33.9292	116.64	1259.712	91.6090
.9	34.2434	118.81	1295.029	93.3133
11	34.5576	121	1331	95.0334
.1	34.8717	123.21	1367.631	96.7691
.2	35.1859	125.44	1404.928	98.5205
.3	35.5010	127.69	1442.897	100.2877
.4	35.8142	129.96	1481.544	102.0705
.5	36.1284	132.25	1520.875	103.8691
.6	36.4425	134.56	1560.896	105.6834
.7	36.7567	136.89	1601.613	107.5134
.8	37.0708	139.24	1643.032	109.3590
.9	37.3840	141.61	1685.159	111.2204
12	37.6992	144	1728	113.0976
.1	38.0133	146.41	1771.561	114.9904
.2	38.3275	148.84	1815.848	116.8989
.3	38.6416	151.29	1860.867	118.8231
.4	38.9558	153.76	1906.624	120.7631
.5	39.2700	156.25	1953.125	122.7187
.6	39.5841	158.76	2000.376	124.6901
.7	39.8983	161.29	2048.383	126.6771
.8	40.2124	163.84	2097.152	128.6799
.9	40.5266	166.41	2146.689	130.6984
13	40.8408	169	2197	132.7326
.1	41.1549	171.61	2248.091	134.7824
.2	41.4691	174.24	2299.968	136.8480
.3	41.7832	176.89	2352.637	138.9294
.4	42.0974	179.56	2406.104	141.0264
.5	42.4116	182.25	2460.375	143.1391
.6	42.7257	184.96	2515.456	145.2675
.7	43.0399	187.69	2571.353	147.4117
.8	43.3540	190.44	2628.072	149.5715
.9	43.6682	193.21	2685.619	151.7471
14	43.9824	196	2744	153.9384
.1	44.2965	198.81	2803.221	156.1453
.2	44.6107	201.64	2863.288	158.3680
.3	44.9248	204.49	2924.207	160.6064
.4	45.2390	207.36	2985.984	162.8605
.5	45.5532	210.25	3048.625	165.1303
.6	45.8673	213.16	3112.136	167.4158
.7	46.1815	216.09	3176.523	169.7170
.8	46.4956	219.04	3241.792	172.0340
.9	46.8098	222.01	3307.949	174.3666

Diam.	Circum.	Square.	Cube.	Area.
15	47.1240	225.	3375	176.7150
.1	47.4381	228.01	3442.951	179.0790
.2	47.7523	231.04	3511.808	181.4588
.3	48.0664	234.09	3581.577	183.8542
.4	48.3806	237.16	3652.264	186.2654
.5	48.6948	240.25	3723.875	188.6923
.6	49.0089	243.36	3796.416	191.1349
.7	49.3231	246.49	3869.893	193.5932
.8	49.6372	249.64	3944.312	196.0672
.9	49.9514	252.81	4019.679	198.5569
16	50.2656	256	4096	201.0624
.1	50.5797	259.21	4173.281	203.5835
.2	50.8939	262.44	4251.528	206.1203
.3	51.2080	265.69	4330.747	208.6729
.4	51.5224	268.96	4410.944	211.2411
.5	51.8364	272.25	4492.125	213.8251
.6	52.1505	275.56	4574.296	216.4248
.7	52.4647	278.89	4657.463	219.0402
.8	52.7788	282.24	4741.632	221.6712
.9	53.0930	285.61	4826.809	224.3180
17	53.4072	289	4913	226.9806
.1	53.7213	292.41	5000.211	229.6588
.2	54.0355	295.84	5088.448	232.3527
.3	54.3496	299.29	5177.717	235.0623
.4	54.6038	302.76	5268.024	237.7877
.5	54.9780	306.25	5359.375	240.5287
.6	55.2921	309.76	5451.776	243.2855
.7	55.6063	313.29	5545.233	246.0579
.8	55.9204	316.84	5639.752	248.8461
.9	56.2346	320.41	5735.339	251.6500
18	56.5488	324	5832	254.4696
.1	56.8629	327.61	5929.741	257.3048
.2	57.1771	331.24	6028.568	260.1558
.3	57.4912	334.89	6128.487	263.0226
.4	57.8054	338.56	6229.504	265.9050
.5	58.1196	342.25	6331.625	268.8031
.6	58.4337	345.96	6434.856	271.7169
.7	58.7479	349.69	6539.203	274.6465
.8	59.0620	353.44	6644.672	277.5917
.9	59.3762	357.21	6751.269	280.5527
19	59.6904	361	6859	283.5294
.1	60.0045	364.81	6967.871	286.5217
.2	60.3187	368.64	7077.888	289.5298
.3	60.6328	372.49	7189.057	292.5536
.4	60.9470	376.36	7301.384	295.5931
.5	61.2612	380.25	7414.875	298.6483
.6	61.5753	384.16	7529.536	301.7192
.7	61.8895	388.09	7645.373	304.8060
.8	62.2036	392.04	7762.392	307.9082
.9	62.5178	396.01	7880.599	311.0262

Diam.	Circum.	Square.	Cube.	Area.
20	62.8320	400	8000	314.1600
.1	63.1461	404.01	8120.601	317.3094
.2	63.4603	408.04	8242.408	320.4746
.3	63.7744	412.09	8365.427	323.6554
.4	64.0886	416.16	8489.664	326.8520
.5	64.4026	420.25	8615.125	330.0643
.6	64.7161	424.36	8741.816	333.2923
.7	65.0311	428.49	8869.743	336.5360
.8	65.3452	432.64	8998.912	339.7954
.9	65.6594	436.81	9129.329	343.0705
21	65.9736	441	9261	346.3614
.1	66.2877	445.21	9393.931	349.6679
.2	66.6019	449.44	9528.128	352.9901
.3	66.9160	453.69	9663.597	356.3281
.4	67.2302	457.96	9800.344	359.6817
.5	67.5444	462.25	9938.375	363.0511
.6	67.8585	466.56	10077.696	366.4362
.7	68.1727	470.89	10218.313	369.8370
.8	68.4868	475.24	10360.232	373.2534
.9	68.8010	479.61	10503.459	376.6856
22	69.1152	484	10648	380.1336
.1	69.4293	488.41	10793.861	383.5972
.2	69.7435	492.84	10941.048	387.0765
.3	70.0576	497.29	11089.567	390.5751
.4	70.3718	501.76	11239.424	394.0823
.5	70.6860	506.25	11390.625	397.6087
.6	71.0001	510.76	11543.176	401.1509
.7	71.3143	515.29	11697.083	404.7087
.8	71.6284	519.84	11852.352	408.2823
.9	71.9426	524.41	12008.989	411.8716
23	72.2568	529	12167	415.4766
.1	72.5709	533.61	12326.391	419.0972
.2	72.8851	538.24	12487.168	422.7336
.3	73.1992	542.89	12649.337	426.3858
.4	73.5134	547.56	12812.904	430.0536
.5	73.8276	552.25	12977.875	433.7371
.6	74.1417	556.96	13144.256	437.4363
.7	74.4559	561.69	13312.053	441.1511
.8	74.7699	566.44	13481.272	444.8819
.9	75.0842	571.21	13651.919	448.6283
24	75.3984	576	13824	452.3904
.1	75.7125	580.81	13997.521	456.1681
.2	76.0267	585.64	14172.488	459.9616
.3	76.3408	590.49	14348.907	463.7708
.4	76.6523	595.36	14526.784	467.5957
.5	76.9692	600.25	14706.125	471.4363
.6	77.2833	605.16	14886.936	475.2926
.7	77.5975	610.09	15069.223	479.1646
.8	77.9116	615.04	15252.992	483.0524
.9	78.2258	620.01	15438.249	486.9558

Diam.	Circum.	Square.	Cube.	Area.
25	78.5400	625	15625	490.8750
.1	78.8541	630.01	15813.251	494.8098
.2	79.1683	635.04	16003.068	498.7604
.3	79.4824	640.09	16194.277	502.7266
.4	79.7966	645.16	16387.064	506.7086
.5	80.8108	650.25	16581.375	510.7063
.6	80.4249	655.36	16777.216	514.7196
.7	80.7391	660.49	16974.593	518.7488
.8	81.0532	665.64	17173.512	522.7936
.9	81.3674	670.81	17373.979	526.8541
26	81.6816	676	17576	530.9304
.1	81.9976	681.21	17779.581	535.0223
.2	82.3099	686.44	17984.728	539.1299
.3	82.6240	691.69	18191.447	543.2533
.4	82.9382	696.96	18399.744	547.3923
.5	83.2524	702.25	18609.625	551.5471
.6	83.5665	707.56	18821.096	555.7176
.7	83.8807	712.89	19034.163	559.9038
.8	84.1948	718.24	19248.832	564.1056
.9	84.5090	723.61	19465.109	568.3232
27	84.8232	729	19683	572.5566
.1	85.1373	734.41	19902.511	576.8056
.2	85.4515	739.84	20123.648	581.0703
.3	85.7656	745.29	20346.417	585.3507
.4	86.0798	750.76	20570.824	589.6469
.5	86.3940	756.25	20796.875	593.9587
.6	86.7081	761.76	21024.576	598.2863
.7	87.0223	767.29	21253.933	602.6295
.8	87.3364	772.84	21484.952	606.9885
.9	87.6506	778.41	21717.639	611.3632
28	87.9648	784	21952	615.7536
.1	88.2789	789.61	22188.041	620.1596
.2	88.5931	795.24	22425.768	624.5814
.3	88.9072	800.89	22665.187	629.0190
.4	89.2214	806.56	22906.304	633.4722
.5	89.5356	812.25	23149.125	637.9411
.6	89.8497	817.96	23393.656	642.4257
.7	90.1639	823.69	23639 903	646.9261
.8	90.4780	829.44	23887.872	651.4421
.9	90.7922	835.21	24137.569	655.9739
29	91.1064	841	24389	660.5214
.1	91.4205	846.81	24642.171	665.0845
.2	91.7347	852.64	24897.088	669.6634
.3	92.0488	858.49	25153.757	674.2580
.4	92.3630	864.36	25412.184	678.8683
.5	92.6772	870.25	25672.375	683.4943
.6	92.9913	876.16	25934.336	688.1360
.7	93.3055	882.09	26198.073	692.7934
.8	93.6196	888.04	26463.592	697.4666
.9	93.9338	894.01	26730.899	702.1554

Diam.	Circum.	Square.	Cube.	Area.
30	94.2480	900	27000	706.8600
.1	94.5621	906.01	27270.901	711.5802
.2	94.8769	912.04	27543.608	716.3162
.3	95.1904	918.09	27818.127	721.0678
.4	95.5046	924.16	28094.464	725.8352
.5	95.8188	930.25	28372.625	730.6183
.6	96.1329	936.36	28652.616	735.4171
.7	96.4471	942.49	28934.443	740.2316
.8	96.7612	948.64	29218.112	745.0618
.9	97.0754	954.81	29503.629	749.9077
31	97.3896	961	29791	754.7694
.1	97.7037	967.21	30080.231	759.6467
.2	98.0179	973.44	30371.328	764.5397
.3	98.3320	979.69	30664.297	769.4485
.4	98.6452	985.96	30959.144	774.3729
.5	98.9604	992.25	31255.875	779.3131
.6	99.2745	998.56	31554.496	784.2689
.7	99.5887	1004.89	31855.013	789.2406
.8	99.9028	1011.24	32157.432	794.2278
.9	100.2170	1017.61	32461.759	799.2308
32	100.5312	1024	32768	804.2496
.1	100.8453	1030.41	33076.161	809.2840
.2	101.1595	1036.84	33386.248	814.3341
.3	101.4736	1043.29	33698.267	819.3999
.4	101.7878	1049.76	34012.224	824.4815
.5	102.1020	1056.25	34328.125	829.5787
.6	102.4161	1062.76	34645.976	834.6917
.7	102.7303	1069.29	34965.783	839.8203
.8	103.0444	1075.84	35287.552	844.9647
.9	103.3586	1082.41	35611.289	850.1248
33	103.6728	1089	35937	855.3006
.1	103.9869	1095.61	36264.691	860.4920
.2	104.3011	1102.24	36594.368	865.6992
.3	104.6151	1108.89	36926.037	870.9222
.4	104.9294	1115.56	37259.704	876.1608
.5	105.2436	1122.25	37595.375	881.4151
.6	105.5577	1128.96	37933.056	886.6851
.7	105.8719	1135.69	38272.753	891.9709
.8	106.1860	1142.44	38614.472	897.2723
.9	106.5002	1149.21	38958.219	902.5895
34	106.8144	1156	39304	907.9224
.1	107.1285	1162.81	39651.821	913.2709
.2	107.4272	1169.64	40001.688	918.6352
.3	107.7568	1176.49	40353.607	924.0115
.4	108.0710	1183.36	40707.584	929.4109
.5	108.3852	1190.25	41063.625	934.8223
.6	108.6993	1197.16	41421.736	940.2494
.7	109.0352	1204.09	41781.923	945.6922
.8	109.3076	1211.04	42144.192	951.1508
.9	109.6418	1218.01	42508.549	956.6250

Diam.	Circum.	Square.	Cube.	Area.
35	109.9560	1225	42875	962.1150
.1	110.2701	1232.01	43243.551	967.6206
.2	110.5843	1239.04	43614.208	973.1420
.3	110.8984	1246.09	43986.977	978.6790
.4	111.2126	1253.16	44361.864	984.2318
.5	111.5268	1260.25	44738.875	989.8003
.6	111.8409	1267.36	45118.016	995.3845
.7	112.1551	1274.49	45499.293	1000.9843
.8	112.4692	1281.64	45882.712	1006.6000
.9	112.7834	1288.81	46268.279	1012.2313
36	113.0976	1296	46656	1017.8784
.1	113.4117	1303.21	47045.831	1023.5411
.2	113.7259	1310.44	47437.928	1029.2195
.3	114.0400	1317.69	47832.147	1034.9131
.4	114.3542	1324.96	48228.544	1040.6235
.5	114.6684	1332.25	48627.125	1046.3491
.6	114.9825	1339.56	49027.896	1052.0904
.7	115.2967	1346.89	49430.863	1057.8474
.8	115.6108	1354.24	49836.032	1063.6200
.9	115.9250	1361.61	50243.409	1069.4084
37	116.2392	1369	50653	1075.2126
.1	116.5533	1376.41	51064.811	1081.0324
.2	116.8675	1383.84	51478.848	1086.8679
.3	117.1816	1391.29	51895.117	1092.7191
.4	117.4958	1398.76	52313.624	1098.5862
.5	117.8100	1406.25	52734.375	1104.4687
.6	118.1241	1413.76	53157.376	1110.3671
.7	118.4383	1421.29	53582.633	1116.2811
.8	118.7524	1428.84	54010.152	1122.2109
.9	119.0666	1436.41	54439.939	1128.1564
38	119.3808	1444	54872	1134.1176
.1	119.6949	1451.61	55306.341	1140.0946
.2	120.0091	1459.24	55742.968	1146.0870
.3	120.3232	1466.89	56181.887	1152.0954
.4	120.6374	1474.56	56623.104	1158.1194
.5	120.9516	1482.25	57066.625	1164.1591
.6	121.2657	1489.96	57512.456	1170.2145
.7	121.5799	1497.69	57960.603	1176.2857
.8	121.8940	1505.44	58411.072	1182.3725
.9	122.2082	1513.21	58863.869	1188.4651
39	122.5224	1521	59319	1294.5394
.1	122.8365	1528.81	59776.471	1200.7273
.2	123.1507	1536.64	60236.288	1206.8770
.3	123.4648	1544.49	60698.457	1213.0424
.4	123.7790	1552.36	61162.984	1219.2243
.5	124.0932	1560.25	61629.875	1225.4203
.6	124.4073	1568.16	62099.136	1231.6326
.7	124.7215	1576.09	62570.773	1237.8610
.8	125.0356	1584.04	63044.792	1244.1210
.9	125.3498	1592.01	63521.199	1250.3646

Diam.	Circum.	Square.	Cube.	Area.
40	125.6640	1600	64000	1256.6400
.1	125.9781	1608.01	64481.201	1262.9310
.2	126.2923	1616.04	64964.808	1269.2388
.3	126.6064	1624.09	65450.827	1275.5602
.4	126.9206	1632.16	65939.264	1281.8984
.5	127.2348	1640.25	66430.125	1288.2523
.6	127.5489	1648.36	66923.416	1294.6219
.7	127.8631	1656.49	67419.143	1301.0071
.8	128.1772	1664.64	67917.312	1307.4082
.9	128.4914	1672.81	68417.929	1313.8249
41	128.8056	1681	68921	1320.2574
.1	129.1197	1689.21	69426.531	1326.7055
.2	129.4339	1697.44	69934.528	1333.1693
.3	129.7480	1705.69	70444.997	1339.6489
.4	130.0622	1713.96	70957.944	1346.1441
.5	130.3764	1722.25	71473.375	1352.6551
.6	130.6905	1730.56	71991.296	1359.1818
.7	131.0047	1738.89	72511.713	1365.7242
.8	131.3188	1747.24	73034.632	1372.2822
.9	131.6320	1755.61	73560.059	1378.8560
42	131.9472	1764	74088	1385.4456
.1	132.2613	1772.41	74618.461	1392.0508
.2	132.5755	1780.84	75151.448	1398.6717
.3	132.8896	1789.29	75686.967	1405.3083
.4	133.2038	1797.76	76225.024	1411.9607
.5	133.5180	1806.25	76765.625	1418.6287
.6	133.8321	1814.76	77308.776	1425.3125
.7	134.1463	1823.29	77854.483	1432.0119
.8	134.4604	1831.84	78402.752	1438.7271
.9	134.7746	1840.41	78953.589	1445.4580
43	135.0888	1849	79507	1452.2046
.1	135.4029	1857.61	80062.991	1458.9668
.2	135.7171	1866.24	80621.568	1465.7448
.3	136.0332	1874.89	81182.737	1472.5385
.4	136.3454	1883.56	81746.504	1479.3480
.5	136.6596	1892.25	82312.875	1486.1731
.6	136.9737	1900.96	82881.856	1493.0139
.7	137.2879	1909.69	83453.453	1499.8705
.8	137.6020	1918.44	84027.672	1506.7427
.9	137.9162	1927.21	84604.519	1513.6287
44	138.2304	1936	85184	1520.5344
.1	138.5445	1944.81	85766.121	1527.4537
.2	138.8587	1953.64	86350.888	1534.3888
.3	139.1728	1962.49	86938.307	1541.3396
.4	139.4870	1971.36	87528.384	1548.3061
.5	139.8012	1980.25	88121.125	1555.2883
.6	140.1153	1989.16	88716.536	1562.2862
.7	140.4295	1998.09	89314.623	1569.2998
.8	140.7436	2007.04	89915.392	1576.3292
.9	141.0578	2016.01	90518.849	1583.3742

Diam.	Circum.	Square.	Cube.	Area.
45	141.3720	2025	91125	1590.4350
.1	141.6861	2034.01	91733.851	1597.5114
.2	142.0003	2043.04	92345.408	1604.6036
.3	142.3144	2052.09	92959.677	1611.7114
.4	142.6286	2061.16	93576.664	1618.8350
.5	142.9428	2070.25	94196.375	1625.9743
.6	143.2569	2079.36	94818.816	1633.1293
.7	143.5711	2088.49	95443.993	1640.3020
.8	143.8852	2097.64	96071.912	1647.4864
.9	144.1994	2106.81	96702.579	1654.6885
46	144.5136	2116	97336	1661.9064
.1	144.8277	2125.21	97972.181	1669.1399
.2	145.1419	2134.44	98611.128	1676.3891
.3	145.4560	2143.69	99252.847	1683.6541
.4	145.7702	2152.96	99897.344	1690.9347
.5	146.0844	2162.25	100544.625	1698.2311
.6	146.3985	2171.56	101194.696	1705.5432
.7	146.7127	2180.89	101847.563	1712.8710
.8	147.0268	2190.24	102503.232	1720.2144
.9	147.3410	2199.61	103161.709	1727.5736
47	147.6552	2209	103823	1734.9486
.1	147.9693	2218.41	104487.111	1742.3392
.2	148.2835	2227.84	105154.048	1749.7455
.3	148.5976	2237.29	105823.817	1757.1675
.4	148.9118	2246.76	106496.424	1764.6045
.5	149.2260	2256.25	107171.875	1772.0587
.6	149.5361	2265.76	107850.176	1779.5279
.7	149.8543	2275.29	108531.333	1787.0127
.8	150.1684	2284.84	109215.352	1794.5133
.9	150.4826	2294.41	109902.239	1802.0296
48	150.7968	2304	110592	1809.5616
.1	151.1109	2313.61	111284.641	1817.1092
.2	151.4251	2323.24	111980.168	1824.6726
.3	151.7392	2332.89	112678.587	1832.2518
.4	152.0534	2342.56	113379.904	1839.8466
.5	152.3676	2352.25	114084.125	1847.4571
.6	152.6817	2361.96	114791.256	1855.0833
.7	152.9959	2371.69	115501.303	1862.7253
.8	153.3100	2381.44	116214.272	1870.3829
.9	153.6242	2391.21	116930.169	1878.0563
49	153.9384	2401	117649	1885.7454
.1	154.2525	2410.81	118370.771	1893.4501
.2	154.5667	2420.64	119095.488	1901.1706
.3	154.8808	2430.49	119823.157	1908.9068
.4	155.1950	2440.36	120553.784	1916.6587
.5	155.5092	2450.25	121287.375	1924.4263
.6	155.8233	2460.16	122023.936	1932.2096
.7	156.1375	2470.09	122763.473	1940.0086
.8	156.4516	2480.04	123505.992	1947.8234
.9	156.7558	2490.01	124251.499	1955.6538

Diam.	Circum.	Square.	Cube.	Area.
50	157.0800	2500	125000	1963.5000
.1	157.3941	2510.01	125751.501	1971.3678
.2	157.7083	2520.04	126506.008	1979.2394
.3	158.0224	2530.09	127263.527	1987.1128
.4	158.3366	2540.16	128024.064	1995.0416
.5	158.6508	2550.25	128787.625	2002.9663
.6	158.9649	2560.36	129554.216	2010.8967
.7	159.2791	2570.49	130323.843	2018.8328
.8	159.5932	2580.64	131096.512	2026.7746
.9	159.9074	2590.81	131872.229	2034.7179
51	160.2216	2601	132651	2042.8254
.1	160.5357	2611.21	133432.831	2050.8443
.2	160.8499	2621.44	134217.728	2058.8784
.3	161.1640	2631.69	135005.697	2066.9283
.4	161.4782	2641.96	135796.744	2074.9683
.5	161.7924	2652.25	136590.875	2083.0771
.6	162.1065	2662.56	137388.096	2091.1746
.7	162.4207	2672.89	138188.413	2099.2778
.8	162.7348	2683.24	138991.832	2107.4166
.9	163.0490	2693.61	139798.359	2115.5612
52	163.3632	2704	140608	2123.7216
.1	163.6773	2714.41	141420.761	2131.8978
.2	163.9915	2724.84	142236.648	2140.0893
.3	164.3056	2735.29	143055.667	2148.2967
.4	164.6198	2745.76	143877.824	2156.5199
.5	164.9340	2756.25	144703.125	2164.7587
.6	165.2481	2766.76	145531.576	2173.0133
.7	165.5623	2777.29	146363.183	2181.2835
.8	165.8764	2787.84	147197.952	2189.5695
.9	166.1906	2798.41	148035.889	2197.8712
53	166.5048	2809	148877	2206.1886
.1	166.8189	2819.61	149721.291	2214.5216
.2	167.1331	2830.24	150568.768	2222.8704
.3	167.4472	2840.89	151419.437	2231.2350
.4	167.7614	2851.56	152273.304	2239.6152
.5	168.0756	2862.25	153130.375	2248.0111
.6	168.3897	2872.96	153990.656	2256.4227
.7	168.7049	2883.69	154854.153	2264.8501
.8	169.0180	2894.44	155720.872	2273.2931
.9	169.3322	2905.21	156590.819	2281.7519
54	169.6464	2916	157464	2290.2264
.1	169.9605	2926.81	158340.421	2298.7165
.2	170.2747	2937.64	159220.088	2307.2224
.3	170.5888	2948.49	160103.007	2315.7440
.4	170.9030	2959.36	160989.184	2324.2813
.5	171.2172	2970.25	161878.625	2332.8343
.6	171.5313	2981.16	162771.336	2341.4030
.7	171.8455	2992.09	163667.323	2349.9875
.8	172.1596	3003.04	164566.592	2358.5876
.9	172.4738	3014.01	165469.149	2367.2035

Diam.	Circum.	Square.	Cube.	Area.
55	172.7880	3025	166375	2375.8350
.1	173.1021	3036.01	167284.151	2384.4822
.2	173.4163	3047.04	168196.608	2393.1452
.3	173.7304	3058.09	169112.377	2401.8238
.4	174.0446	3069.16	170031.464	2410.5182
.5	174.3588	3080.25	170953.875	2419.2283
.6	174.6729	3091.36	171879.616	2427.9541
.7	174.9771	3102.49	172808.693	2436.6956
.8	175.3092	3113.64	173741.112	2445.4528
.9	175.6154	3124.81	174676.879	2454.2257
56	175.9296	3136	175616	2463.0144
.1	176.2437	3147.21	176558.481	2471.8187
.2	176.5579	3158.44	177504.328	2480.6387
.3	176.8720	3169.69	178453.547	2489.4745
.4	177.1862	3180.96	179406.144	2498.3259
.5	177.5004	3192.25	180362.125	2507.1931
.6	177.8145	3203.56	181321.496	2516.0760
.7	178.1287	3214.89	182284.263	2524.9746
.8	178.4428	3226.24	183250.432	2533.8888
.9	178.7570	3237.61	184220.009	2542.8188
57	179.0712	3249	185193	2551.7646
.1	179.3853	3260.41	186169.411	2560.7260
.2	179.6995	3271.84	187149.248	2569.7031
.3	180.0136	3283.29	188132.517	2578.6959
.4	180.3278	3294.76	189119.224	2587.7045
.5	180.6420	3306.25	190109.375	2596.7287
.6	180.9561	3317.76	191102.976	2605.7687
.7	181.2803	3329.29	192100.033	2614.8243
.8	181.5844	3340.84	193100.552	2623.8957
.9	181.8986	3352.41	194104.539	2632.9828
58	182.2128	3364	195112	2642.0856
.1	182.5269	3375.61	196122.941	2651.2046
.2	182.8411	3387.24	197137.368	2660.3382
.3	183.1552	3398.89	198155.287	2669.4882
.4	183.4694	3410.56	199176.704	2678.6538
.5	183.7836	3422.25	200201.625	2687.8351
.6	184.0977	3433.96	201230.056	2697.0321
.7	184.4119	3445.69	202262.003	2706.2449
.8	184.7260	3457.44	203297.472	2715.4733
.9	185.0402	3469.21	204336.469	2724.7175
59	185.3544	3481	205379	2733.9774
.1	185.6685	3492.81	206425.071	2743.2529
.2	185.9827	3504.64	207474.688	2752.5442
.3	186.2696	3516.49	208527.857	2761.8512
.4	186.6110	3528.36	209584.584	2771.1739
.5	186.9252	3540.25	210644.875	2780.5123
.6	187.2393	3552.16	211708.736	2789.8664
.7	187.5535	3564.09	212776.173	2799.2362
.8	187.8676	3576.04	213847.192	2808.6218
.9	188.1818	3588.01	214921.799	2818.0230

Diam.	Circum.	Square.	Cube.	Area.
60	188.4960	3600	216000	2827.4400
.1	188.8101	3612.01	217081.801	2836.8726
.2	189.1243	3624.04	218167.208	2846.3210
.3	189.4384	3636.09	219256.227	2855.7850
.4	189.7526	3648.16	220348.864	2865.2648
.5	190.0668	3660.25	221445.125	2874.7603
.6	190.3809	3672.36	222545.016	2884.2615
.7	190.6951	3684.49	223648.543	2893.7984
.8	191.0092	3696.64	224755.712	2903.3410
.9	191.3234	3708.81	225866.529	2912.8993
61	191.6376	3721	226981	2922.4734
.1	191.9517	3733.21	228099.131	2932.0631
.2	192.2659	3745.44	229220.928	2941.6685
.3	192.5800	3757.69	230346.397	2951.2897
.4	192.8942	3769.96	231475.544	2960.9265
.5	193.2084	3782.25	232608.375	2970.5791
.6	193.5225	3794.56	233744.896	2980.2474
.7	193.8367	3806.89	234885.113	2989.9314
.8	194.1508	3819.24	236029.032	2999.6300
.9	194.4650	3831.61	237176.659	3009.3464
62	194.7792	3844	238328	3019.0776
.1	195.0933	3856.41	239483.061	3028.8244
.2	195.4075	3868.84	240641.848	3038.5869
.3	195.7216	3881.29	241804.367	3048.3651
.4	196.0358	3893.76	242970.624	3058.1591
.5	196.3500	3906.25	244140.625	3067.9687
.6	196.6641	3918.76	245314.376	3077.7941
.7	196.9783	3931.29	246491.883	3087.6341
.8	197.2924	3943.84	247673.152	3097.4919
.9	197.6066	3956.41	248858.189	3107.3644
63	197.9208	3969	250047	3117.2526
.1	198.2349	3981.61	251239.591	3127.1564
.2	198.5491	3994.24	252435.968	3137.0758
.3	198.8632	4006.89	253636.137	3147.0114
.4	199.1774	4019.56	254840.104	3156.9664
.5	199.4916	4032.25	256047.875	3166.9291
.6	199.8057	4044.96	257259.456	3176.9115
.7	200.1199	4057.69	258474.853	3186.9097
.8	200.4340	4070.44	259694.072	3196.9235
.9	200.7482	4083.21	260917.119	3206.9531
64	201.0624	4096	262144	3216.9984
.1	201.3765	4108.81	263374.721	3227.0593
.2	201.6907	4121.64	264609.288	3237.1360
.3	202.0048	4134.49	265847.707	3247.2284
.4	202.3190	4147.36	267089.984	3257.3365
.5	202.6332	4160.25	268336.125	3267.4602
.6	202.9473	4173.16	269586.136	3277.5996
.7	203.2615	4186.09	270840.023	3287.7546
.8	203.5756	4199.04	272097.792	3297.9253
.9	203.8898	4212.01	273359.449	3308.1116

Diam.	Circum.	Square.	Cube.	Area.
65	204.2040	4225	274625	3318.3150
.1	204.5181	4238.01	275894.451	3328.5340
.2	204.8323	4251.04	277167.808	3338.7663
.3	205.1464	4264.09	278445.077	3349.0162
.4	205.4606	4277.16	279726.264	3359.2814
.5	205.7748	4290.25	281011.375	3369.5623
.6	206.0889	4303.36	282300.416	3379.8589
.7	206.4031	4316.49	283593.393	3390.1712
.8	206.7172	4329.64	284890.312	3400.4992
.9	207.0314	4342.81	286191.179	3410.8429
66	207.3456	4356	287496	3421.2024
.1	207.6597	4369.21	288804.781	3431.5775
.2	207.9739	4382.44	290117.528	3441.9683
.3	208.2880	4395.69	291434.247	3452.3749
.4	208.6022	4408.96	292754.944	3462.7971
.5	208.9164	4422.25	294079.625	3473.2351
.6	209.2305	4435.56	295408.296	3483.6888
.7	209.5447	4448.89	296740.963	3494.1640
.8	209.8588	4462.24	298077.632	3504.6432
.9	210.1730	4475.61	299418.309	3515.1430
67	210.4872	4489	300763	3525.6606
.1	210.8013	4502.41	302111.711	3536.1938
.2	211.1155	4515.84	303464.448	3546.7407
.3	211.4296	4529.29	304821.217	3557.3043
.4	211.7438	4542.76	306182.024	3567.8837
.5	212.0580	4556.25	307546.875	3578.4787
.6	212.3721	4569.76	308915.776	3589.0895
.7	212.6863	4583.29	310288.733	3599.7159
.8	213.0004	4596.84	311665.752	3610.3581
.9	213.3146	4610.41	313046.839	3621.0160
68	213.6288	4624	314432	3631.6896
.1	213.9429	4637.61	315821.241	3642.3788
.2	214.2571	4651.24	317214.568	3653.0838
.3	214.5712	4664.89	318611.987	3663.8040
.4	214.8854	4678.56	320013.504	3674.5410
.5	215.1996	4692.25	321419.125	3685.2931
.6	215.5137	4705.96	322828.856	3696.0060
.7	215.8279	4719.69	324242.703	3706.8445
.8	216.1420	4733.44	325660.672	3717.6437
.9	216.4562	4747.21	327082.769	3728.4587
69	216.7704	4761	328509	3739.2894
.1	217.0845	4774.81	329939.371	3750.1357
.2	217.3987	4788.64	331373.888	3760.9978
.3	217.7128	4802.49	332812.557	3771.8756
.4	218.0270	4816.36	334255.384	3782.7691
.5	218.3412	4830.25	335702.375	3793.6783
.6	218.6553	4844.16	337153.536	3804.6032
.7	218.9695	4858.09	338608.873	3815.5438
.8	219.2836	4872.04	340068.392	3826.5002
.9	219.5978	4886.01	341532.099	3837.4722

Diam.	Circum.	Square.	Cube.	Area.
70	219.9120	4900	343000	3848.4600
.1	220.2261	4914.01	344472.101	3859.4952
.2	220.5403	4928.04	345948.408	3870.4826
.3	220.8544	4942.09	347428.927	3881.5174
.4	221.1686	4956.16	348913.664	3892.5680
.5	221.4828	4970.25	350402.625	3903.6343
.6	221.7969	4984.36	351895.816	3914.7163
.7	222.1111	4998.49	353393.243	3925.8140
.8	222.4252	5012.64	354894.912	3936.9274
.9	222.7394	5026.81	356400.829	3948.0565
71	223.0536	5041	357911	3959.2014
.1	223.3677	5055.21	359425.431	3970.3619
.2	223.6819	5069.44	360944.128	3981.5381
.3	223.9960	5083.69	362467.097	3992.7301
.4	224.3102	5097.96	363994.344	4003.9373
.5	224.6244	5112.25	365525.875	4015.1611
.6	224.9385	5126.56	367061.696	4026.4002
.7	225.2527	5140.89	368601.813	4037.6550
.8	225.5668	5155.24	370146.232	4048.9254
.9	225.8810	5169.61	371694.959	4060.2116
72	226.1952	5184	373248	4071.5136
.1	226.5093	5198.41	374805.361	4082.8332
.2	226.8235	5212.84	376367.048	4094.1645
.3	227.1376	5227.29	377933.067	4105.5125
.4	227.4518	5241.76	379503.424	4116.8793
.5	227.7660	5256.25	381078.125	4128.2587
.6	228.0801	5270.76	382657.176	4139.6524
.7	228.3943	5285.29	384240.583	4151.0667
.8	228.7084	5299.84	385828.352	4162.4943
.9	229.0226	5314.41	387420.489	4173.9376
73	229.3368	5329	389017	4185.3966
.1	229.6509	5343.61	390617.891	4196.8712
.2	229.9651	5358.24	392223.168	4208.3614
.3	230.2792	5372.89	393832.837	4219.8673
.4	230.5934	5387.56	395446.904	4231.3896
.5	230.9076	5402.25	397065.375	4242.9271
.6	231.2217	5416.96	398688.256	4254.4803
.7	231.5359	5431.69	400315.553	4266.0493
.8	231.8500	5446.44	401947.272	4277.6339
.9	232.1642	5461.21	403583.419	4289.2343
74	232.4784	5476	405224	4300.8504
.1	232.7925	5490.81	406869.021	4312.4821
.2	233.1067	5505.64	408518.488	4324.1296
.3	233.4208	5520.49	410172.407	4335.7928
.4	233.7350	5535.36	411830.784	4347.4717
.5	234.0492	5550.25	413493.625	4359.1663
.6	234.3633	5565.16	415160.936	4370.8766
.7	234.6775	5580.09	416832.723	4382.6026
.8	234.9916	5595.04	418508.992	4394.3443
.9	235.3058	5610.01	420189.749	4406.1018

Diam.	Circum.	Square.	Cube.	Area.
75	235.6200	5625	421875	4417.8750
.1	235.9341	5640.01	423564.751	4429.6638
.2	236.2483	5655.04	425259.008	4441.4684
.3	236.5624	5670.09	426957.777	4453.2886
.4	236.8766	5685.16	428661.064	4465.1246
.5	237.1908	5700.25	430368.875	4476.9763
.6	237.5049	5715.36	432081.216	4488.8437
.7	237.8191	5730.49	433798.093	4500.7268
.8	238.1332	5745.64	435519.512	4512.6256
.9	238.4474	5760.81	437245.479	4524.5401
76	238.7616	5776	438976	4536.4704
.1	239.0757	5791.21	440711.081	4548.4163
.2	239.3899	5806.44	442450.728	4560.3781
.3	239.7040	5821.69	444194.947	4572.3553
.4	240.0182	5836.96	445943.744	4584.3483
.5	240.3324	5852.25	447697.125	4596.3571
.6	240.6465	5867.56	449455.096	4608.3816
.7	240.9607	5882.89	451217.663	4620.4218
.8	241.2748	5898.24	452984.832	4632.4776
.9	241.5987	5913.61	454756.609	4644.5492
77	241.9032	5929	456533	4656.6366
.1	242.2173	5944.41	458314.011	4668.7396
.2	242.5315	5959.84	460099.648	4680.8583
.3	242.8456	5975.29	461889.917	4692.9927
.4	243.1598	5990.76	463684.824	4705.1429
.5	243.4740	6006.25	465484.375	4717.3087
.6	243.7881	6021.76	467288.576	4729.4903
.7	244.1023	6037.29	469097.433	4741.6875
.8	244.4164	6052.84	470910.952	4753.9005
.9	244.7306	6068.41	472729.139	4766.1292
78	245.0448	6084	474552	4778.3736
.1	245.3589	6099.61	476379.541	4790.6336
.2	245.6731	6115.24	478211.768	4802.9094
.3	245.9872	6130.89	480048.687	4815.2010
.4	246.3014	6146.56	481890.304	4827.5082
.5	246.6156	6162.25	483736.625	4839.8311
.6	246.9297	6177.96	485587.656	4852.1697
.7	247.2439	6193.69	487443.403	4864.5241
.8	247.5480	6209.44	489303.872	4876.8973
.9	247.8722	6225.21	491169.069	4889.2799
79	248.1864	6241	493039	4901.6814
.1	248.5005	6256.81	494913.671	4914.0985
.2	248.8147	6272.64	496793.088	4926.5314
.3	249.1288	6288.49	498677.257	4938.9820
.4	249.4430	6304.36	500566.184	4951.4443
.5	249.7572	6320.25	502459.875	4963.9243
.6	250.0713	6336.16	504358.336	4976.4200
.7	250.3855	6352.09	506261.573	4988.9313
.8	250.6996	6368.04	508169.592	5001.4
.9	251.0138	6384.01	510082.399	5014.0

Diam.	Circum.	Square.	Cube.	Area.
80	251.3280	6400	512000	5026.5600
.1	251.6421	6416.01	513922.401	5039.1342
.2	251.9563	6432.04	515849.608	5051.7242
.3	252.2704	6448.09	517781.627	5064.3298
.4	252.5846	6464.16	519718.464	5076.9552
.5	252.8988	6480.25	521660.125	5089.5883
.6	253.2129	6496.36	523606.616	5102.2411
.7	253.5271	6512.49	525557.943	5114.9096
.8	253.8412	6528.64	527514.112	5127.5938
.9	254.1554	6544.81	529475.129	5140.2937
81	254.4696	6561	531441	5153.0094
.1	254.7837	6577.21	533411.731	5165.7407
.2	255.0979	6593.44	535387.328	5178.4877
.3	255.4120	6609.69	537367.797	5191.2505
.4	255.7262	6625.96	539353.144	5204.0285
.5	256.0404	6642.25	541343.375	5216.8231
.6	256.3545	6658.56	543338.496	5229.6330
.7	256.6687	6674.89	545338.513	5242.4586
.8	256.9828	6691.24	547343.432	5255.2998
.9	257.2970	6707.61	549353.259	5268.1568
82	257.6112	6724	551368	5281.0296
.1	257.9253	6740.41	553387.661	5293.9180
.2	258.2395	6756.84	555412.248	5306.8221
.3	258.5536	6773.29	557441.767	5319.7439
.4	258.8646	6789.76	559476.224	5332.6775
.5	259.1820	6806.25	561515.625	5345.6287
.6	259.4961	6822.76	563559.976	5358.5957
.7	259.8103	6839.29	565609.283	5371.5983
.8	260.1244	6855.84	567663.552	5384.5762
.9	260.4386	6872.41	569722.789	5397.5908
83	260.7528	6889	571787	5410.6206
.1	261.0669	6905.61	573856.191	5423.6660
.2	261.3811	6922.24	575930.368	5436.7272
.3	261.6952	6938.89	578009.537	5449.8042
.4	262.0094	6955.56	580093.704	5462.8968
.5	262.3236	6972.25	582182.875	5476.0051
.6	262.6376	6988.96	584277.056	5489.1291
.7	262.9519	7005.69	586376.253	5502.2689
.8	263.2660	7022.44	588480.472	5515.4243
.9	263.5802	7039.21	590589.719	5528.5953
84	263.8944	7056	592704	5541.7824
.1	264.2085	7072.81	594823.321	5554.9849
.2	264.5227	7089.64	596947.688	5568.2032
.3	264.8368	7106.49	599077.107	5581.4372
.4	265.1510	7123.36	601211.584	5294.6869
.5	265.4652	7140.25	603351.125	5607.9523
.6	265.7793	7157.16	605495.736	5621.2334
.7	266.0935	7174.09	607645.423	5634.5302
.8	266.4076	7191.04	609800.192	5647.8428
.9	266.7218	7208.01	611960.049	5661.1710

Diam.	Circum.	Square.	Cube.	Area.
85	267.0360	7225	614125	5674.5150
.1	267.3501	7242.01	616295.051	5687.8746
.2	267.6643	7259.04	618470.208	5701.2500
.3	267.9784	7276.09	620650.477	5714.6410
.4	268.2926	7293.16	622835.864	5728.0478
.5	268.6068	7310.25	625026.375	5741.4703
.6	268.9209	7327.36	627222.016	5754.9085
.7	269.2351	7344.49	629422.793	5768.3624
.8	269.5492	7361.64	631628.712	5781.8320
.9	269.8634	7378.81	633839.779	5795.3173
86	270.1776	7396	636056	5808.8184
.1	270.4917	7413.21	638277.381	5822.3351
.2	270.8059	7430.44	640503.928	5835.8675
.3	271.1200	7447.69	642735.647	5849.4157
.4	271.4342	7464.96	644972.544	5862.9795
.5	271.7484	7482.25	647214.625	5876.5591
.6	272.0665	7499.56	649461.896	5890.1541
.7	272.3767	7516.89	651714.363	5903.7654
.8	272.6908	7534.24	653972.032	5917.3920
.9	273.0050	7551.61	656234.909	5931.0344
87	273.3192	7569	658503	5944.6926
.1	273.6333	7586.41	660776.311	5958.3644
.2	273.9875	7603.84	663054.848	5972.0559
.3	274.2616	7621.29	665338.617	5985.7691
.4	274.5758	7638.76	667627.624	5999.4821
.5	274.8900	7656.25	669921.875	6013.2187
.6	275.2041	7673.76	672221.376	6026.9711
.7	275.5183	7691.29	674526.133	6040.7391
.8	275.8324	7708.84	676836.152	6054.5149
.9	276.1466	7726.41	679151.439	6068.3224
88	276.4608	7744	681472	6082.1376
.1	276.7749	7761.61	683797.841	6095.9684
.2	277.0891	7779.24	686128.968	6109.8150
.3	277.4032	7796.89	688465.387	6123.6774
.4	277.7174	7814.56	690807.104	6137.5554
.5	278.0316	7832.25	693154.125	6151.4491
.6	278.3457	7849.96	695506.456	6165.3585
.7	278.6599	7867.69	697864.103	6179.2837
.8	278.9750	7885.44	700227.072	6193.2245
.9	279.2882	7903.21	702595.369	6207.1811
89	279.6024	7921	704969	6221.1534
.1	279.9165	7938.81	707347.971	6235.1413
.2	280.2307	7956.64	709732.288	6249.1450
.3	280.5448	7974.49	712121.957	6263.1644
.4	280.8590	7992.36	714516.984	6277.1995
.5	281.1732	8010.25	716917.375	6291.2033
.6	281.4873	8028.16	719323.136	6305.3168
.7	281.8825	8046.09	721734.273	6319.3990
.8	282.1156	8064.04	724150.792	6333.4970
.9	282.4298	8082.01	726572.699	6347.6013

Diam.	Circum.	Square.	Cube.	Area.
90	282.7440	8100	729000	6361.7400
.1	283.0581	8118.01	731432.701	6375.8850
.2	283.3723	8136.04	733870.808	6390.0452
.3	283.6864	8154.09	736314.327	6404.2222
.4	284.0006	8172.16	738763.264	6418.4144
.5	284.3148	8190.25	741217.625	6432.6223
.6	284.6289	8208.36	743677.416	6446.8474
.7	284.9431	8226.49	746142.643	6461.0852
.8	285.2572	8244.64	748613.312	6475.3402
.9	285.5714	8262.81	751089.429	6489.6109
91	285.8856	8281	753571	6503.8974
.1	286.1997	8299.21	756058.031	6518.1995
.2	286.5139	8317.44	758550.528	6532.5173
.3	286.8290	8335.69	761048.497	6546.8509
.4	287.1422	8353.96	763551.944	6561.2001
.5	287.4564	8372.25	766060.875	6575.5651
.6	287.7705	8390.56	768575.296	6589.9458
.7	288.0847	8408.89	771095.213	6604.3422
.8	288.3988	8427.24	773620.632	6618.7542
.9	288.7130	8445.61	776151.559	6633.1820
92	289.0272	8464	778688	6647.6256
.1	289.3413	8482.41	781229.961	6662.0848
.2	289.6555	8500.84	783777.448	6676.5597
.3	289.9696	8519.29	786330.467	6691.0161
.4	290.2838	8537.76	788889.024	6705.5567
.5	290.5980	8556.25	791453.125	6720.0767
.6	290.9121	8574.76	794022.776	6734.6165
.7	291.2263	8593.29	796597.983	6749.1669
.8	291.5404	8611.84	799178.752	6763.7331
.9	291.8546	8630.41	801765.089	6778.3249
93	292.1688	8649	804357	6792.9246
.1	292.4829	8667.61	806954.491	6807.5402
.2	292.7971	8686.24	809557.568	6822.1720
.3	293.1112	8704.89	812166.237	6836.8206
.4	293.4254	8723.56	814780.504	6851.4840
.5	293.7396	8742.25	817400.375	6866.1631
.6	294.0537	8760.96	820025.856	6880.8579
.7	294.3679	8779.69	822656.953	6895.5685
.8	294.6820	8798.44	825293.672	6910.2947
.9	294.9962	8817.21	827936.019	6925.0367
94	295.3104	8836	830584	6939.7944
.1	295.6245	8854.81	833237.021	6954.5677
.2	295.9387	8873.64	835896.888	6969.3568
.3	296.2436	8892.49	838561.807	6984.1614
.4	296.5670	8911.36	841232.384	6998.9821
.5	296.8812	8930.25	843908.625	7013.8186
.6	297.1953	8949.16	846590.536	7028.6708
.7	297.5095	8968.09	849278.123	7043.5388
.8	297.8236	8987.04	851971.392	7058.4225
.9	298.1378	9006.01	854670.349	7073.3222

Diam.	Circum.	Area.	Diam.	Circum.	Area.
10 in.	31.4160	78.5400	16 in.	50.2656	201.0624
⅛	31.8087	80.5157	⅛	50.6583	204.2162
¼	32.2014	82.5160	¼	51.0510	207.3946
⅜	32.5941	84.5409	⅜	51.4437	210.5976
½	32.9868	86.5903	½	51.8364	213.8251
⅝	33.3795	88.6643	⅝	52.2291	217.0772
¾	33.7722	90.7627	¾	52.6218	220.3537
⅞	34.1649	92.8858	⅞	53.0145	223.6549
11 in.	34.5576	95.0334	17 in.	53.4072	226.9806
⅛	34.9503	97.2055	⅛	53.7999	230.3308
¼	35.3430	99.4021	¼	54.1926	233.7055
⅜	35.7357	101.6234	⅜	54.5853	237.1049
½	36.1284	103.8691	½	54.9780	240.5287
⅝	36.5211	106.1394	⅝	55.3707	243.9771
¾	36.9138	108.4342	¾	55.7634	247.4500
⅞	37.3065	110.7536	⅞	56.1561	250.9475
12 in.	37.6992	113.0976	18 in.	56.5488	254.4696
⅛	38.0919	115.4660	⅛	56.9415	258.0161
¼	38.4846	117.8590	¼	57.3342	261.5872
⅜	38.8773	120.2766	⅜	57.7269	265.1829
½	39.2700	122.7187	½	58.1196	268.8031
⅝	39.6627	125.1854	⅝	58.5123	272.4479
¾	40.0554	127.6765	¾	58.9050	276.1171
⅞	40.4481	130.1923	⅞	59.2977	279.8110
13 in.	40.8408	132.7326	12 in.	59.6904	283.5294
⅛	41.2335	135.2974	⅛	60.0831	287.2723
¼	41.6262	137.8867	¼	60.4758	291.0397
⅜	42.0189	140.5007	⅜	60.8685	294.8312
½	42.4116	143.1391	½	61.2612	298.6483
⅝	42.8043	145.8021	⅝	61.6539	302.4894
¾	43.1970	148.4896	¾	62.0466	306.3550
⅞	43.5897	151.2017	⅞	62.4393	310.2452
14 in.	43.9824	153.9384	20 in.	62.8320	314.1600
⅛	44.3751	156.6995	⅛	63.2247	318.0992
¼	44.7678	159.4852	¼	63.6174	322.0630
⅜	45.1605	162.2956	⅜	64.0101	326.0514
½	45.5532	165.1303	½	64.4028	330.0643
⅝	45.9459	167.9896	⅝	64.7955	334.1018
¾	46.3386	170.8735	¾	65.1882	338.1637
⅞	46.7313	173.7820	⅞	65.5809	342.2503
15 in.	47.1240	176.7150	21 in.	65.9736	346.3614
⅛	47.5167	179.6725	⅛	66.3663	350.4970
¼	47.9094	182.6545	¼	66.7590	354.6571
⅜	48.3021	185.6612	⅜	67.1517	358.8419
½	48.6948	188.6923	½	67.5444	363.0511
⅝	49.0875	191.7480	⅝	67.9371	367.2849
¾	49.4802	194.8282	¾	68.3298	371.5432
⅞	49.8729	197.9330	⅞	68.7225	375.8261

TABLE IX,

Containing the circumferences and areas of circles, from one-eighth to 100 inches, advancing by an eighth.

Diam.	Circum.	Area.	Diam.	Circum.	Area.
			5 in.	15.7080	19.6350
⅛	.3927	.0122	⅛	16.1007	20.6290
¼	.7854	.0490	¼	16.4934	21.6475
⅜	1.1781	.1104	⅜	16.8861	22.6907
½	1.5708	.1963	½	17.2788	23.7583
⅝	1.9635	.3068	⅝	17.6715	24.8505
¾	2.3562	.4417	¾	18.0642	25.9672
⅞	2.7489	.6013	⅞	18.4569	27.1085
1 in.	3.1416	.7854	6 in.	18.8496	28.2744
⅛	3.5343	.9940	⅛	19.2423	29.4647
¼	3.9270	1.2271	¼	19.6350	30.6796
⅜	4.3197	1.4848	⅜	20.0277	31.9192
½	4.7124	1.7671	½	20.4204	33.1831
⅝	5.1051	2.0739	⅝	20.8131	34.4717
¾	5.4978	2.4052	¾	21.2058	35.7847
⅞	5.8905	2.7611	⅞	21.5985	37.1224
2 in.	6.2832	3.1416	7 in.	21.9912	38.4846
⅛	6.6759	3.5465	⅛	22.3839	39.8713
¼	7.0686	3.9760	¼	22.7766	41.2825
⅜	7.4613	4.4302	⅜	23.1693	42.7184
½	7.8540	4.9087	½	23.5620	44.1787
⅝	8.2467	5.4119	⅝	23.9547	45.6636
¾	8.6394	5.9395	¾	24.3474	47.1730
⅞	9.0321	6.4918	⅞	24.7401	48.7070
3 in.	9.4248	7.0686	8 in.	25.1328	50.2656
⅛	9.8175	7.6699	⅛	25.5255	51.8486
¼	10.2102	8.2957	¼	25.9182	53.4562
⅜	10.6029	8.9462	⅜	26.3109	55.0885
½	10.9956	9.6211	½	26.7036	56.7451
⅝	11.3883	10.3206	⅝	27.0963	58.4264
¾	11.7810	11.0446	¾	27.4890	60.1321
⅞	12.1737	11.7932	⅞	27.8817	61.8625
4 in.	12.5664	12.5664	9 in.	28.2744	63.6174
⅛	12.9591	13.3640	⅛	28.6671	65.3968
¼	13.3518	14.1862	¼	29.0598	67.2007
⅜	13.7445	15.0331	⅜	29.4525	69.0292
½	14.1372	15.9043	½	29.8452	70.8822
⅝	14.5299	16.8001	⅝	30.2379	72.7599
¾	14.9226	17.7205	¾	30.6306	74.6620
⅞	15.3153	18.6655	⅞	31.0233	76.5887

Diam.	Circum.	Area.	Diam.	Circum.	Area.
34 in.	106.8144	907.9224	40 in.	125.6640	1256.6400
⅛	107.2071	914.6105	⅛	126.0567	1264.5062
¼	107.5998	921.3232	¼	126.4494	1272.3970
⅜	107.9925	928.0605	⅜	126.8421	1280.3124
½	108.3852	934.8223	½	127.2348	1288.2523
⅝	108.7779	941.6087	⅝	127.6275	1296.2168
¾	109.1706	948.4195	¾	128.0202	1304.2057
⅞	109.5633	955.2550	⅞	128.4129	1312.2193
35 in.	109.9560	962.1150	41 in.	128.8056	1320.2574
⅛	110.3487	968 9995	⅛	129.1983	1328.3200
¼	110.7414	975.9085	¼	129.5910	1336.4071
⅜	111.1341	982.8422	⅜	129.9837	1344.5189
½	111.5268	989.8003	½	130.3764	1352.6551
⅝	111.9195	996.7830	⅝	130.7691	1360.8159
¾	112.3122	1003.7902	¾	131.1618	1369.0012
⅞	112.7049	1010.8220	⅞	131.5545	1377.2111
36 in.	113.0977	1017.8784	42 in.	131.9472	1385.4456
⅛	113.4903	1024.9592	⅛	132.3399	1393.7045
¼	113.8830	1032.0646	¼	132.7326	1401.9880
⅜	114.2757	1039.1946	⅜	133.1253	1410.2961
½	114.6684	1046.3491	½	133.5180	1418.6287
⅝	115.0611	1053.5281	⅝	133.9107	1426.9859
¾	115.4538	1060.7317	¾	134.3034	1435.3675
⅞	115.8465	1067.9599	⅞	134.6961	1443.7738
37 in.	116.2392	1075.2126	43 in.	135.0888	1452.2046
⅛	116.6319	1082.4898	⅛	135.4815	1460.6599
¼	117.0246	1089.7915	¼	135.8742	1469.1397
⅜	117.4173	1097.1179	⅜	136.2669	1477.6342
½	117.8100	1104.4687	½	136.6596	1486.1731
⅝	118.2027	1111.8441	⅝	137.0523	1494.7266
¾	118.5954	1119.2440	¾	137.4450	1503.3046
⅞	118.9881	1126.6685	⅞	137.8377	1511.9072
38 in.	119.3808	1134.1176	44 in.	138.2304	1520.5344
⅛	119.7735	1141.5911	⅛	138.6231	1529.1860
¼	120.1662	1149.0892	¼	139.0158	1537.8622
⅜	120.5589	1156.6119	⅜	139.4085	1546.5530
½	120.9516	1164.1591	½	139.8012	1555.2883
⅝	121.3443	1171.7309	⅝	140.1939	1564.0382
¾	121.7370	1179.3271	¾	140.5866	1572.8125
⅞	122.1297	1186.9480	⅞	140.9793	1581.6115
39 in.	122.5224	1194.5934	45 in.	141.3720	1590.4350
⅛	122.9151	1202.2633	⅛	141.7647	1599.2830
¼	123.3078	1209.9577	¼	142.1574	1608.1555
⅜	123.7005	1217.6768	⅜	142.5505	1617.0427
½	124.0932	1225.4203	½	142.9428	1625.9743
⅝	124.4859	1233.1884	⅝	143.3355	1634.9205
¾	124.8786	1240.9810	¾	143.7282	1643.8912
⅞	125.2713	1248.7982	⅞	144.1209	1652.8865

Diam.	Circum.	Area.	Diam.	Circum.	Area.
22 *in.*	69.1152	380.1336	28 *in.*	87.9648	615.7536
⅛	69.5079	384.4655	⅛	88.3575	621.2636
¼	69.9006	388.8220	¼	88.7502	626.7902
⅜	70.2933	393.2031	⅜	89.1429	632.3574
½	70.6860	397.6087	½	89.5356	637.9411
⅝	71.0787	402.0388	⅝	89.9283	643.5494
¾	71.4714	406.4935	¾	90.3210	649.1821
⅞	71.8641	410.9728	⅞	90.7137	654.8395
23 *in.*	72.2568	415.4766	29 *in.*	91.1064	660.5214
⅛	72.6495	420.0049	⅛	91.4991	666.2278
¼	73.0422	424.5577	¼	91.8918	671.9587
⅜	73.4349	429.1352	⅜	92.2845	677.7143
½	73.8276	433.7371	½	92.6772	683.4943
⅝	74.2203	438.3636	⅝	93.0699	689.2989
¾	74.6130	443.0146	¾	93.4626	695.1280
⅞	75.0057	447.6902	⅞	93.8553	700.9817
24 *in.*	75.3984	452.3904	30 *in.*	94.2480	706.8600
⅛	75.7911	457.1150	⅛	94.6407	712.7627
¼	76.1838	461.8642	¼	95.0334	718.6900
⅜	76.5765	466.6380	⅜	95.4261	724.6419
½	76.9692	471.4363	½	95.8188	730.6183
⅝	77.3619	476.2592	⅝	96.2115	736.6193
¾	77.7546	481.1065	¾	96.6042	742.6447
⅞	78.1473	485.9785	⅞	96.9969	748.6948
25 *in.*	78.5400	490.8750	31 *in.*	97.3896	754.7694
⅛	78.9327	495.7960	⅛	97.7823	760.8685
¼	79.3254	500.7415	¼	98.1750	766.9921
⅜	79.7181	505.7117	⅜	98.5677	773.1404
½	80.1108	510.7063	½	98.9604	779.3131
⅝	80.5035	515.7255	⅝	99.3531	785.5104
¾	80.8962	520.7692	¾	99.7458	791.7322
⅞	81.2889	525.8375	⅞	100.1385	797.9786
26 *in.*	81.6816	530.9304	32 *in.*	100.5312	804.2496
⅛	82.0743	536.0477	⅛	100.9239	810.5450
¼	82.4670	541.1896	¼	101.3166	816.8650
⅜	82.8597	546.3561	⅜	101.7093	823.2096
½	83.2524	551.5471	½	102.1020	829.5787
⅝	83.6451	556.7627	⅝	102.4947	835.9724
¾	84.0378	562.0027	¾	102.8874	842.3905
⅞	84.4305	567.2674	⅞	103.2801	848.8333
27 *in.*	84.8232	572.5566	33 *in.*	103.6728	855.3006
⅛	85.2159	577.8703	⅛	104.0655	861.7924
¼	85.6086	583.2085	¼	104.4582	868.3087
⅜	86.0013	588.5714	⅜	104.8509	874.8497
½	86.3940	593.9587	½	105.2436	881.4151
⅝	86.7867	599.3706	⅝	105.6363	888.0051
¾	87.1794	604.8070	¾	106.0290	894.6196
⅞	87.5721	610.2680	⅞	106.4217	901.2587

Diam.	Circum.	Area.	Diam.	Circum.	Area.
58 in.	182.2128	2642.0656	64 in.	201.0624	3216.9984
⅛	182.6055	2653.4861	⅛	201.4551	3229.5770
¼	182.9982	2664.9112	¼	201.8478	3242.1782
⅜	183.3909	2676.3609	⅜	202.2405	3254.8020
½	183.7836	2687.8351	½	202.6332	3267.4483
⅝	184.1763	2699.3338	⅝	203.0259	3280.1372
¾	184.5690	2710.8571	¾	203.4186	3292.8385
⅞	184.9617	2722.4050	⅞	203.8113	3305.5643
59 in.	185.3544	2733.9774	65 in.	204.2040	3318.3150
⅛	185.7471	2745.5743	⅛	204.5967	3331.0900
¼	186.1398	2757.1957	¼	204.9894	3343.8875
⅜	186.5325	2768.8418	⅜	205.3821	3356.7137
½	186.9252	2780.5123	½	205.7748	3369.5623
⅝	187.3179	2792.2074	⅝	206.1675	3382.4355
¾	187.7106	2803.9270	¾	206.5602	3395.3332
⅞	188.1033	2815.6712	⅞	206.9529	3408.2555
60 in.	188.4960	2827.4400	66 in.	207.3456	3421.2024
⅛	188.8887	2839.2332	⅛	207.7383	3434.1737
¼	189.2814	2851.0510	¼	208.1310	3447.1676
⅜	189.6741	2862.8934	⅜	208.5237	3460.1901
½	190.0668	2874.7603	½	208.9164	3473.2351
⅝	190.4595	2886.6517	⅝	209.3091	3486.3047
¾	190.8522	2898.5677	¾	209.7018	3499.3987
⅞	191.2449	2910.5083	⅞	210.0945	3512.5174
61 in.	191.6376	2922.4734	67 in.	210.4872	3525.6606
⅛	192.0303	2934.4630	⅛	210.8799	3538.8283
¼	192.4230	2946.4771	¼	211.2726	3552.0185
⅜	192.8157	2958.5159	⅜	211.6653	3565.2374
½	193.2084	2970.5791	½	212.0580	3578.4787
⅝	193.6011	2982.6669	⅝	212.4507	3591.7446
¾	193.9938	2994.7792	¾	212.8434	3605.0350
⅞	194.3865	3006.9161	⅞	213.2361	3618.3500
62 in.	194.7792	3019.0776	68 in.	213.6288	3631.6896
⅛	195.1719	3031.2635	⅛	214.0215	3645.0536
¼	195.5646	3043.4740	¼	214.4142	3658.4422
⅜	195.9573	3055.7091	⅜	214.8069	3671.8554
½	196.3500	3067.9687	½	215.1996	3685.2931
⅝	196.7427	3080.2529	⅝	215.5923	3698.7554
¾	197.1354	3092.5615	¾	215.9850	3712.2421
⅞	197.5281	3104.8948	⅞	216.3777	3725.7535
63 in.	197.9208	3117.2526	69 in.	216.7704	3739.2894
⅛	198.3135	3129.6349	⅛	217.1631	3752.8498
¼	198.7062	3142.0417	¼	217.5558	3766.4327
⅜	199.0989	3154.4732	⅜	217.9485	3780.0443
½	199.4916	3166.9291	½	218.3412	3793.6783
⅝	199.8843	3179.4096	⅝	218.7339	3807.3369
¾	200.2770	3191.9146	¾	219.1266	3821.0200
⅞	200.6697	3204.4442	⅞	219.5193	3834.7277

Diam.	Circum.	Area.	Diam.	Circum.	Area.
46 in.	144.5136	1661.9064	52 in.	163.3632	2123.7216
⅛	144.9063	1670.9507	⅛	163.7559	2133.9440
¼	145.2990	1680.0196	¼	164.1486	2144.1910
⅜	145.6917	1689.1031	⅜	164.5413	2154.4626
½	146.0844	1698.2311	½	164.9340	2164.7587
⅝	146.4771	1707.3737	⅝	165.3267	2175.0794
¾	146.8698	1716.5407	¾	165.7194	2185.4245
⅞	147.2625	1725.7324	⅞	166.1121	2195.7943
47 in.	147.6552	1734.9486	53 in.	166.5048	2206.1886
⅛	148.0479	1744.1893	⅛	166.8975	2216.6074
¼	148.4406	1753.4545	¼	167.2902	2227.0507
⅜	148.8333	1762.7344	⅜	167.6829	2237.5187
½	149.2260	1772.0587	½	168.0756	2248.0111
⅝	149.6187	1781.3976	⅝	168.4683	2258.5281
¾	150.0114	1790.7610	¾	168.8610	2269.0696
⅞	150.4041	1800.1490	⅞	169.2537	2279.6357
48 in.	150.7968	1809.5616	54 in.	169.6464	2290.2264
⅛	151.1895	1818.9986	⅛	170.0391	2300.8415
¼	151.5822	1828.4602	¼	170.4318	2311.4812
⅜	151.9749	1837.9364	⅜	170.8245	2322.1455
½	152.3676	1847.4571	½	171.2172	2332.8343
⅝	152.7603	1856.9924	⅝	171.6099	2343.5477
¾	153.1530	1866.5521	¾	172.0026	2354.2855
⅞	153.5457	1876.1365	⅞	172.3953	2365.0480
49 in.	153.9384	1885.7454	55 in.	172.7880	2375.8350
⅛	154.3311	1895.3788	⅛	173.1807	2386.6465
¼	154.7238	1905.0367	¼	173.5734	2397.4825
⅜	155.1165	1914.7093	⅜	173.9661	2408.3432
½	155.5092	1924.4263	½	174.3588	2419.2283
⅝	155.9019	1934.1579	⅝	174.7515	2430.1380
¾	156.2946	1943.9140	¾	175.1442	2441.0722
⅞	156.6873	1953.6947	⅞	175.5369	2452.0310
50 in.	157.0800	1963.5000	56 in.	175.9296	2463.0144
⅛	157.4727	1973.3297	⅛	176.3223	2474.0222
¼	157.8654	1983.1840	¼	176.7150	2485.0546
⅜	158.2581	1993.0529	⅜	177.1077	2496.1116
½	158.6508	2002.9663	½	177.5004	2507.1931
⅝	159.0435	2012.8943	⅝	177.8931	2518.2992
¾	159.4362	2022.8467	¾	178.2858	2529.4297
⅞	159.8289	2032.8238	⅞	178.6785	2540.5849
51 in.	160.2216	2042.8254	57 in.	179.0712	2551.7646
⅛	160.6143	2052.8515	⅛	179.4639	2562.9688
¼	161.0070	2062.9021	¼	179.8566	2574.1975
⅜	161.3997	2072.9674	⅜	180.2493	2585.4508
½	161.7924	2083.0771	½	180.6420	2596.7287
⅝	162.1851	2093.2014	⅝	181.0347	2608.0311
¾	162.5778	2103.3502	¾	181.4274	2619.3580
⅞	162.9705	2113.5236	⅞	181.8201	2630.7095

Diam.	Circum.	Area.	Diam.	Circum.	Area.
82 in.	257.6112	5281.0296	88 in.	276.4606	6082.1376
⅛	258.0039	5297.1426	⅛	276.8535	6099.4287
¼	258.3866	5313.2780	¼	277.2462	6116.7422
⅜	258.7993	5329.4421	⅜	277.6389	6134.0844
½	259.1820	5345.6287	½	278.0316	6151.4491
⅝	259.5747	5361.8391	⅝	278.4243	6168.8376
¾	259.9674	5378.0755	¾	278.8170	6186.2521
⅞	260.3601	5394.3358	⅞	279.2097	6203.6905
83 in.	260.7528	5410.6296	89 in.	279.6024	6221.1534
⅛	261.1455	5426.9299	⅛	279.9951	6238.6408
¼	261.5382	5443.2617	¼	280.3878	6256.1507
⅜	261.9309	5459.6222	⅜	280.7805	6273.6893
½	262.3236	5476.0051	½	281.1732	6291.2503
⅝	262.7163	5492.4118	⅝	281.5659	6308.8351
¾	263.1090	5508.8446	¾	281.9586	6326.4460
⅞	263.5017	5525.3012	⅞	282.3513	6344.0807
84 in.	263.8944	5541.7824	90 in.	282.7440	6361.7400
⅛	264.2871	5558.2881	⅛	283.1367	6379.4238
¼	264.6798	5574.8162	¼	283.5294	6397.1300
⅜	265.0725	5591.3730	⅜	283.9221	6414.8649
½	265.4652	5607.9523	½	284.3148	6432.6223
⅝	265.8579	5624.5554	⅝	284.7075	6450.4039
¾	266.2506	5641.1845	¾	285.1002	6468.2107
⅞	266.6433	5657.8357	⅞	285.4929	6486.0418
85 in.	267.0360	5674.5150	91 in.	285.8856	6503.8974
⅛	267.4287	5691.2170	⅛	286.2783	6521.7775
¼	267.8214	5707.9415	¼	286.6710	6539.6801
⅜	268.2141	5724.6947	⅜	287.0637	6557.6114
½	268.6068	5741.4703	½	287.4564	6575.5651
⅝	268.9995	5758.2697	⅝	287.8491	6593.5431
¾	269.3922	5775.0952	¾	288.2418	6611.5462
⅞	269.7849	5791.9445	⅞	288.6345	6629.5736
86 in.	270.1776	5808.8184	92 in.	289.0272	6647.6258
⅛	270.5703	5825.7168	⅛	289.4199	6665.7021
¼	270.9630	5842.6376	¼	289.8126	6683.8010
⅜	271.3557	5859.5871	⅜	290.2053	6701.9286
½	271.7484	5876.5591	½	290.5980	6720.0787
⅝	272.1411	5893.5549	⅝	290.9907	6738.2530
¾	272.5338	5910.5767	¾	291.3834	6756.4525
⅞	272.9265	5927.6224	⅞	291.7761	6774.6763
87 in.	273.3192	5944.6926	93 in.	292.1688	6792.9248
⅛	273.7119	5961.7873	⅛	292.5615	6811.1974
¼	274.1046	5978.9045	¼	292.9542	6829.4927
⅜	274.4973	5996.0504	⅜	293.3469	6847.8167
½	274.8900	6013.2187	½	293.7396	6866.1637
⅝	275.2827	6030.4108	⅝	294.1323	6884.5338
¾	275.6754	6047.6290	¾	294.5250	6902.9290
⅞	276.0681	6064.8710	⅞	294.9177	6921.3487

Diam.	Circum.	Area.	Diam.	Circum.	Area.
70 in.	219.9120	3848.4600	76 in.	238.7616	4536.4704
⅛	220.3047	3862.2167	⅛	239.1543	4551.4023
¼	220.6974	3875.9960	¼	239.5470	4566.3626
⅜	221.0901	3889.8039	⅜	239.9397	4581.3486
½	221.4828	3903.6343	½	240.3324	4596.3571
⅝	221.8755	3917.4893	⅝	240.7251	4611.3902
¾	222.2682	3931.3687	¾	241.1178	4626.4477
⅞	222.6609	3945.2728	⅞	241.5105	4641.5299
71 in.	223.0536	3959.2014	77 in.	241.9032	4656.6366
⅛	223.4463	3973.1545	⅛	242.2959	4671.7678
¼	223.8390	3987.1301	¼	242.6866	4686.9215
⅜	224.2317	4001.1344	⅜	243.0813	4702.1039
½	224.6244	4015.1611	½	243.4740	4717.3087
⅝	225.0171	4029.2124	⅝	243.8667	4732.5381
¾	225.4098	4043.2882	¾	244.2594	4747.7920
⅞	225.8025	4057.3886	⅞	244.6521	4763.0705
72 in.	226.1952	4071.5136	78 in.	245.0448	4778.3736
⅛	226.5879	4085.6631	⅛	245.4375	4793.7012
¼	226.9806	4099.8350	¼	245.8302	4809.0512
⅜	227.3733	4114.0356	⅜	246.2229	4824.4299
½	227.7660	4128.2587	½	246.6156	4839.8311
⅝	228.1587	4142.5064	⅝	247.0083	4855.2568
¾	228.5514	4156.7785	¾	247.4010	4870.7071
⅞	228.9441	4171.0753	⅞	247.7937	4886.1820
73 in.	229.3368	4185.3966	79 in.	248.1864	4901.6814
⅛	229.7295	4199.7424	⅛	248.5791	4917.2053
¼	230.1222	4214.1107	¼	248.9718	4932.7517
⅜	230.5149	4228.5077	⅜	249.3645	4948.3268
½	230.9076	4242.9271	½	249.7572	4963.9243
⅝	231.3003	4257.3711	⅝	250.1499	4979.5456
¾	231.6930	4271.8396	¾	250.5426	4995.1930
⅞	232.0857	4286.3327	⅞	250.9353	5010.8642
74 in.	232.4784	4300.8504	80 in.	251.3280	5026.5600
⅛	232.8711	4315.3926	⅛	251.7207	5042.2803
¼	233.2638	4329.9572	¼	252.1134	5058.0230
⅜	233.6565	4344.5505	⅜	252.5061	5073.7944
½	234.0492	4359.1663	½	252.8988	5089.5883
⅝	234.4419	4373.8067	⅝	253.2915	5105.4060
¾	234.8346	4388.4715	¾	253.6842	5121.2497
⅞	235.2273	4403.1610	⅞	254.0769	5137.1173
75 in.	235.6200	4417.8750	81 in.	254.4696	5153.0094
⅛	236.0127	4432.6135	⅛	254.8623	5168.9260
¼	236.4054	4447.3745	¼	255.2550	5184.8651
⅜	236.7981	4462.1642	⅜	255.6477	5200.8329
½	237.1908	4476.9763	½	256.0404	5216.8231
⅝	237.5835	4491.8130	⅝	256.4331	5232.8371
¾	237.9762	4506.6742	¾	256.8258	5248.8772
⅞	238.3689	4521.5600	⅞	257.2185	5264.9411

TABLE X,

Containing the circumferences and areas of circles from 1 to 50 feet, and advancing by an inch.

Diam.	Circum.	Area.	Diam.	Circum.	Area.
1 *ft.*	3.1416	.7854	4 *ft.*	12.5664	12.5664
1	3.4034	.9217	1	12.8282	13.0952
2	3.6652	1.0690	2	13.0900	13.6353
3	3.9270	1.2271	3	13.3518	14.1862
4	4.1888	1.3962	4	13.6136	14.7479
5	4.4506	1.5761	5	13.8754	15.3206
6	4.7124	1.7671	6	14.1372	15.9043
7	4.9742	1.9689	7	14.3990	16.4986
8	5.2360	2.1816	8	14.6608	17.1041
9	5.4978	2.4052	9	14.9226	17.7205
10	5.7596	2.6398	10	15.1844	18.3476
11	6.0214	2.8852	11	15.4462	18.9858
2 *ft.*	6.2832	3.1416	5 *ft.*	15.7080	19.6350
1	6.5450	3.4087	1	15.9698	20.2947
2	6.8068	3.6869	2	16.2316	20.9656
3	7.0686	3.9760	3	16.4934	21.6475
4	7.3304	4.2760	4	16.7552	22.3400
5	7.5922	4.5869	5	17.0170	23.0437
6	7.8540	4.9087	6	17.2788	23.7583
7	8.1158	5.2413	7	17.5406	24.4835
8	8.3776	5.5850	8	17.8024	25.2199
9	8.6394	5.9395	9	18.0642	25.9672
10	8.9012	6.3049	10	18.3260	26.7251
11	9.1630	6.6813	11	18.5878	27.4943
3 *ft.*	9.4248	7.0686	6 *ft.*	18.8496	28.2744
1	9.6866	7.4666	1	19.1114	29.0649
2	9.9484	7.8757	2	19.3732	29.8668
3	10.2102	8.2957	3	19.6350	30.6796
4	10.4720	8.7265	4	19.8968	31.5029
5	10.7338	9.1683	5	20.1586	32.2376
6	10.9956	9.6211	6	20.4204	33.1831
7	11.2574	10.0846	7	20.6822	34.0391
8	11.5192	10.5591	8	20.9440	34.9065
9	11.7810	11.0446	9	21.2058	35.7847
10	12.0428	11.5409	10	21.4676	36.6735
11	12.3046	12.0481	11	21.7294	37.5736

Diam.	Circum.	Area.	Diam.	Circum.	Area.
94 *in.*	295.3104	6939.7946	97 *in.*	304.7352	7389.8288
⅛	295.7031	6958.2636	⅛	305.1279	7408.8868
¼	296.0958	6976.7552	¼	305.5206	7427.9675
⅜	296.4885	6995.2755	⅜	305.9133	7447.0769
½	296.8812	7013.8183	½	306.3060	7466.2087
⅝	297.2739	7032.3853	⅝	306.6987	7485.3648
¾	297.6666	7050.9775	¾	307.0914	7504.5460
⅞	298.0593	7069.5940	⅞	307.4841	7523.7515
95 *in.*	298.4520	7088.2352	98 *in.*	307.8768	7542.9818
⅛	298.8447	7106.9005	⅛	308.2695	7562.2362
¼	299.2374	7125.5885	¼	306.6622	7581.5132
⅜	299.6301	7144.3052	⅜	309.0549	7600.8189
½	300.0228	7163.0443	½	309.4476	7620.1471
⅝	300.4155	7181.8077	⅝	309.8403	7639.4995
¾	300.8082	7200.5962	¾	310.2230	7658.8771
⅞	301.2009	7219.4090	⅞	310.6257	7678.2790
96 *in.*	301.5936	7238.2466	99 *in.*	311.0184	7697.7056
⅛	301.9863	7257.1083	⅛	311.4111	7717.1563
¼	302.3790	7275.9926	¼	311.8038	7736.6297
⅜	302.7717	7294.9056	⅜	312.1965	7756.1318
½	303.1644	7313.8411	½	312.5892	7775.6563
⅝	303.5571	7332.8008	⅝	312.9819	7795.2051
¾	303.9498	7351.7857	¾	313.3746	7814.7790
⅞	304.3425	7370.7949	⅞	313.7673	7834.3772
			100 *in.*	314.1600	7854.0000

Diam.	Circum.	Area.	Diam.	Circum.	Area.
15 *ft.*	47.1240	176.7150	19 *ft.*	59.6904	283.5294
1	47.3858	178.6832	1	59.9522	286.0210
2	47.6476	180.6634	2	60.2140	288.5249
3	47.9094	182.6545	3	60.4758	291.0397
4	48.1712	184.6555	4	60.7376	293.5641
5	48.4330	186.6684	5	60.9994	296.1007
6	48.6948	188.6923	6	61.2612	298.6483
7	48.9566	190.7260	7	61.5230	301.2054
8	49.2184	192.7716	8	61.7848	303.7747
9	49.4802	194.8282	9	62.0466	306.3550
10	49.7420	196.8946	10	62.3084	308.9448
11	50.0038	198.9730	11	62.5702	311.5469
16 *ft.*	50.2656	201.0624	20 *ft.*	62.8320	314.1600
1	50.5274	203.1615	1	63.0938	316.7824
2	50.7892	205.2726	2	63.3556	319.4173
3	51.0510	207.3946	3	63.6174	322.0630
4	51.3128	209.5264	4	63.8792	324.7182
5	51.5746	211.6703	5	64.1410	327.2858
6	51.8364	213.8251	6	64.4028	330.0643
7	52.0982	215.9896	7	64.6646	332.7522
8	52.3600	218.1662	8	64.9264	335.4525
9	52.6218	220.3537	9	65.1882	338.1637
10	52.8836	222.5510	10	65.4500	340.8844
11	53.1454	224.7603	11	65.7118	343.6174
17 *ft.*	53.4072	226.9806	21 *ft.*	65.9736	346.3614
1	53.6690	229.2105	1	66.2354	349.1147
2	53.9308	231.4525	2	66.4972	351.8804
3	54.1926	233.7055	3	66.7590	354.6571
4	54.4544	235.9682	4	67.0208	357.4432
5	54.7162	238.2430	5	67.2826	360.2417
6	54.9780	240.5287	6	67.5444	363.0511
7	55.2398	242.8241	7	67.8062	365.8698
8	55.5016	245.1316	8	68.0680	368.7011
9	55.7634	247.4500	9	68.3298	371.5432
10	56.0252	249.7781	10	68.5916	374.3947
11	56.2870	252.1184	11	68.8534	377.2587
18 *ft.*	56.5488	254.4696	22 *ft.*	69.1152	380.1336
1	56.8106	256.8303	1	69.3770	383.0177
2	57.0724	259.2033	2	69.6388	385.9144
3	57.3342	261.5872	3	69.9006	388.8220
4	57.5960	263.9807	4	70.1624	391.7389
5	57.8578	266.3864	5	70.4242	394.6683
6	58.1196	268.8031	6	70.6860	397.6087
7	58.3814	271.2293	7	70.9478	400.5583
8	58.6432	273.6678	8	71.2096	403.5204
9	58.9050	276.1171	9	71.4714	406.4935
10	59.1668	278.5761	10	71.7332	409.4759
11	59.4286	281.0472	11	71.9950	412.4707

Diam.	Circum.	Area.	Diam.	Circum.	Area.
23 *ft.*	72.2568	415.4766	27 *ft.*	84.8232	572.5566
1	72.5186	418.4915	1	85.0850	576.0949
2	72.7804	421.5192	2	85.3468	579.6463
3	73.0422	424.5577	3	85.6086	583.2085
4	73.3040	427.6055	4	85.8704	586.7796
5	73.5658	430.6658	5	86.1322	590.3637
6	73.8276	433.7371	6	86.3940	593.9587
7	74.0894	436.8175	7	86.6558	597.5625
8	74.3512	439.9106	8	86.9176	601.1793
9	74.6130	443.0146	9	87.1794	604.8070
10	74.8748	446.1278	10	87.4412	608.4436
11	75.1366	449.2536	11	87.7030	612.0931
24 *ft.*	75.3984	452.3904	28 *ft.*	87.9648	615.7536
1	75.6602	455.5362	1	88.2266	619.4228
2	75.9220	458.6948	2	88.4884	623.1050
3	76.1838	461.8642	3	88.7502	626.7982
4	76.4456	465.0428	4	89.0120	630.5002
5	76.7074	468.2341	5	89.2738	634.2152
6	76.9692	471.4363	6	89.5356	637.9411
7	77.2310	474.6476	7	89.7974	641.6758
8	77.4928	477.8716	8	90.0592	645.4235
9	77.7546	481.1065	9	90.3210	649.1821
10	78.0164	484.3506	10	90.5828	652.9495
11	78.2782	487.6073	11	90.8446	656.7300
25 *ft.*	78.5400	490.8750	29 *ft.*	91.1064	660.5214
1	78.8018	494.1516	1	91.3682	664.3214
2	79.0636	497.4411	2	91.6300	668.1346
3	79.3254	500.7415	3	91.8918	671.9587
4	79.5872	504.0510	4	92.1536	675.7915
5	79.8490	507.3732	5	92.4154	679.6375
6	80.1108	510.7063	6	92.6772	683.4943
7	80.3726	514.0484	7	92.9390	687.3598
8	80.6344	517.4034	8	93.2008	691.2385
9	80.8962	520.7692	9	93.4626	695.1280
10	81.1580	524.1441	10	93.7244	699.0263
11	81.4198	527.5318	11	93.9862	702.9377
26 *ft.*	81.6816	530.9304	30 *ft.*	94.2480	706.8600
1	81.9434	534.3379	1	94.5098	710.7909
2	82.2052	537.7583	2	94.7716	714.7350
3	82.4670	541.1896	3	95.0334	718.6900
4	82.7288	544.6299	4	95.2952	722.6537
5	82.9906	548.0830	5	95.5570	726.6305
6	83.2524	551.5471	6	95.8186	730.6183
7	83.5142	555.0201	7	96.0806	734.6147
8	83.7760	558.5059	8	96.3424	738.6242
9	84.0378	562.0027	9	96.6042	742.6447
10	84.2996	565.5084	10	96.8660	746.6738
11	84.5614	569.0270	11	97.1278	750.7161

Diam.	Circum.	Area.	Diam.	Circum.	Area.
31 *ft.*	97.3896	754.7694	35 *ft.*	109.9560	962.1150
1	97.6514	758.8311	1	110.2178	966.7001
2	97.9132	762.9062	2	110.4796	971.2989
3	98.1750	766.9921	3	110.7414	975.9085
4	98.4368	771.0866	4	111.0032	980.5264
5	98.6986	775.1944	5	111.2650	985.1579
6	98.9604	779.3131	6	111.5268	989.8003
7	99.2222	783.4403	7	111.7886	994.4509
8	99.4840	787.5808	8	112.0504	999.1151
9	99.7458	791.7322	9	112.3122	1003.7902
10	100.0076	795.8922	10	112.5740	1008.4736
11	100.2694	800.0654	11	112.8358	1013.1705
32 *ft.*	100.5312	804.2496	36 *ft.*	113.0976	1017.8784
1	100.7930	808.4422	1	113.3594	1022.5944
2	101.0548	812.6481	2	113.6212	1027.3240
3	101.3166	816.8650	3	113.8830	1032.0646
4	101.5784	821.0904	4	114.1448	1036.8134
5	101.8402	825.3291	5	114.4066	1041.5758
6	102.1020	829.5787	6	114.6684	1046.3491
7	102.3638	833.8368	7	114.9302	1051.1306
8	102.6256	838.1082	8	115.1920	1055.9257
9	102.8874	842.3905	9	115.4538	1060.7317
10	103.1492	846.6813	10	115.7756	1065.5459
11	103.4110	850.9855	11	115.9774	1070.3738
33 *ft.*	103.6728	855.3006	37 *ft.*	116.2392	1075.2126
1	103.9346	859.6240	1	116.5010	1080.0594
2	104.1964	863.9609	2	116.7628	1084.9201
3	104.4582	868.3087	3	117.0246	1089.7915
4	104.7200	872.6649	4	117.2864	1094.6711
5	104.9818	877.0346	5	117.5482	1099.5644
6	105.2436	881.4151	6	117.8100	1104.4687
7	105.5054	885.8040	7	118.0718	1109.3810
8	105.7672	890.2064	8	118.3336	1114.3071
9	106.0290	894.6196	9	118.5954	1119.2440
10	106.2908	899.0413	10	118.8572	1124.1891
11	106.5526	903.4763	11	119.1190	1129.1478
34 *ft.*	106.8144	907.9224	38 *ft.*	119.3808	1134.1176
1	107.0762	912.3767	1	119.6426	1139.0953
2	107.3380	916.8445	2	119.9044	1144.0868
3	107.5998	921.3222	3	120.1662	1149.0892
4	107.8616	925.8103	4	120.4280	1154.0997
5	108.1234	930.3108	5	120.6898	1159.1239
6	108.3852	934.8223	6	120.9516	1164.1591
7	108.6470	939.3421	7	121.2134	1169.2023
8	108.9088	943.8753	8	121.4752	1174.2592
9	109.1706	948.4195	9	121.7370	1179.3271
10	109.4324	952.9720	10	121.9988	1184.4030
11	109.6942	957.5380	11	122.2606	1189.4857

Diam.	Circum.	Area.	Diam.	Circum.	Area.
23 *ft.*	72.2568	415.4766	27 *ft.*	84.8232	572.5566
1	72.5186	418.4915	1	85.0850	576.0949
2	72.7804	421.5192	2	85.3468	579.6463
3	73.0422	424.5577	3	85.6086	583.2085
4	73.3040	427.6055	4	85.8704	586.7796
5	73.5658	430.6658	5	86.1322	590.3637
6	73.8276	433.7371	6	86.3940	593.9587
7	74.0894	436.8175	7	86.6558	597.5625
8	74.3512	439.9106	8	86.9176	601.1793
9	74.6130	443.0146	9	87.1794	604.8070
10	74.8748	446.1278	10	87.4412	608.4436
11	75.1366	449.2536	11	87.7030	612.0931
24 *ft.*	75.3984	452.3904	28 *ft.*	87.9648	615.7536
1	75.6602	455.5362	1	88.2266	619.4228
2	75.9220	458.6948	2	88.4884	623.1050
3	76.1838	461.8642	3	88.7502	626.7982
4	76.4456	465.0428	4	89.0120	630.5002
5	76.7074	468.2341	5	89.2738	634.2152
6	76.9692	471.4363	6	89.5356	637.9411
7	77.2310	474.6476	7	89.7974	641.6758
8	77.4928	477.8716	8	90.0592	645.4235
9	77.7546	481.1065	9	90.3210	649.1821
10	78.0164	484.3506	10	90.5828	652.9495
11	78.2782	487.6073	11	90.8446	656.7300
25 *ft.*	78.5400	490.8750	29 *ft.*	91.1064	660.5214
1	78.8018	494.1516	1	91.3682	664.3214
2	79.0636	497.4411	2	91.6300	668.1346
3	79.3254	500.7415	3	91.8918	671.9587
4	79.5872	504.0510	4	92.1536	675.7915
5	79.8490	507.3732	5	92.4154	679.6375
6	80.1108	510.7063	6	92.6772	683.4943
7	80.3726	514.0484	7	92.9390	687.3598
8	80.6344	517.4034	8	93.2008	691.2385
9	80.8962	520.7692	9	93.4626	695.1280
10	81.1580	524.1441	10	93.7244	699.0263
11	81.4198	527.5318	11	93.9862	702.9377
26 *ft.*	81.6816	530.9304	30 *ft.*	94.2480	706.8600
1	81.9434	534.3379	1	94.5098	710.7909
2	82.2052	537.7583	2	94.7716	714.7350
3	82.4670	541.1896	3	95.0334	718.6900
4	82.7288	544.6299	4	95.2952	722.6537
5	82.9906	548.0830	5	95.5570	726.6305
6	83.2524	551.5471	6	95.8188	730.6182
7	83.5142	555.0201	7	96.0806	734.6145
8	83.7760	558.5059	8	96.3424	738.6181
9	84.0378	562.0027	9	96.6042	742.6447
10	84.2996	565.5084	10	96.8660	746.6780
11	84.5614	569.0270	11	97.1278	750.7181

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
47 *ft.*	147.6552	1734.9486	48 7	152.6294	1853.8087
1	147.9170	1741.1039	8	152.8912	1860.1750
2	148.1788	1747.2738	9	153.1530	1866.5521
3	148.4406	1753.4545	10	153.4148	1872.9365
4	148.7024	1759.6426	11	153.6766	1879.3355
5	148.9642	1765.8452	49 *ft.*	153.9384	1885.7454
6	149.2260	1772.0587	1	154.2002	1892.1724
7	149.4878	1778.2795	2	154.4620	1898.5041
8	149.7496	1784.5148	3	154.7238	1905.0367
9	150.0114	1790.7610	4	154.9856	1911.4965
10	150.2732	1797.0145	5	155.2474	1917.9609
11	150.5350	1803.2826	6	155.5092	1924.4263
48 *ft.*	150.7968	1809.5616	7	155.7710	1930.9188
1	151.0586	1815.8477	8	156.0328	1937.3159
2	151.3204	1822.1485	9	156.2946	1943.9140
3	151.5822	1828.4602	10	156.5564	1950.4392
4	151.8440	1834.7791	11	156.8182	1956.9691
5	152.1058	1841.1127	50 *ft.*	157.0800	1963.5000
6	152.3676	1847.4571			

TABLE XI,

Containing the superficies and solid content of spheres, from 1 *to* 12, *and advancing by a tenth.*

Diam.	*Superficies.*	*Solidity.*	*Diam.*	*Superficies.*	*Solidity.*
1.0	3.1416	.5236	2.5	19.6350	8.1812
.1	3.8013	.6969	.6	21.2372	9.2027
.2	4.5239	.9047	.7	22.9022	10.3060
.3	5.3093	1.1503	.8	24.6300	11.4940
.4	6.1575	1.4367	.9	26.4208	12.7700
.5	7.0686	1.7671	3.0	28.2744	14.1372
.6	8.0424	2.1446	.1	30.1907	15.5985
.7	9.0792	2.5724	.2	32.1699	17.1573
.8	10.1787	3.0536	.3	34.2120	18.8166
.9	11.3411	3.5913	.4	36.3168	20.5795
2.0	12.5664	4.1888	.5	38.4846	22.4493
.1	13.8544	4.8490	.6	40.7151	24.4290
.2	15.2053	5.5752	.7	43.0085	26.5219
.3	16.6190	6.3706	.8	45.3647	28.7309
.4	18.0956	7.2382	.9	47.7837	31.0594

Diam.	Circum.	Area.	Diam.	Circum.	Area.
39 ft.	122.5224	1194.5934	43 ft.	135.0888	1452.2946
1	122.7842	1199.7195	1	135.3506	1457.8065
2	123.0460	1204.8244	2	135.6124	1463.4827
3	123.3078	1209.9577	3	135.8742	1469.1397
4	123.5696	1215.0990	4	136.1360	1474.8044
5	123.8314	1220.2542	5	136.3978	1480.4833
6	124.0932	1225.4203	6	136.6596	1486.1731
7	124.3550	1230.5943	7	136.9214	1491.8705
8	124.6168	1235.7822	8	137.1832	1497.5821
9	124.8786	1240.9810	9	137.4450	1503.3046
10	125.1404	1246.1878	10	137.7068	1509.0348
11	125.4022	1251.4084	11	137.9686	1514.7791
40 ft.	125.6640	1256.6400	44 ft.	138.2304	1520.5344
1	125.9258	1261.8794	1	138.4922	1526.2971
2	126.1876	1267.1327	2	138.7540	1532.0742
3	126.4494	1272.3970	3	139.0158	1537.8622
4	126.7112	1277.6692	4	139.2776	1543.6578
5	126.9730	1282.9553	5	139.5394	1549.4676
6	127.2348	1288.2523	6	139.8012	1555.2883
7	127.4966	1293.5572	7	140.0630	1561.1165
8	127.7584	1298.8760	8	140.3248	1566.9591
9	128.0202	1304.2057	9	140.5866	1572.8125
10	128.2820	1309.5433	10	140.8484	1578.6735
11	128.5438	1314.8949	11	141.1102	1584.5488
41 ft.	128.8056	1320.2574	45 ft.	141.3720	1590.4350
1	129.0674	1325.6276	1	141.6338	1596.3286
2	129.3292	1331.0119	2	141.8956	1602.2366
3	129.5910	1336.4071	3	142.1574	1608.1555
4	129.8528	1341.8101	4	142.4192	1614.0819
5	130.1146	1347.2271	5	142.6810	1620.0226
6	130.3764	1352.6551	6	142.9428	1625.9743
7	130.6382	1358.0908	7	143.2046	1631.9334
8	130.9000	1363.5406	8	143.4664	1637.9068
9	131.1618	1369.0012	9	143.7282	1643.8912
10	131.4236	1374.4697	10	143.9900	1649.8831
11	131.6854	1379.9521	11	144.2518	1655.8892
42 ft.	131.9472	1385.4456	46 ft.	144.5136	1661.9064
1	132.2090	1390.2467	1	144.7754	1667.9308
2	132.4708	1396.4619	2	145.0372	1673.9698
3	132.7326	1401 9880	3	145.2990	1680.0196
4	132.9944	1407.5219	4	145.5608	1686.0769
5	133.2562	1413.0698	5	145.8226	1692.1485
6	133.5180	1418.6287	6	146.0844	1698.2311
7	133.7798	1424.1952	7	146.3462	1704.3210
8	134.0416	1429.7759	8	146.6080	1710.4254
9	134.3034	1435.3675	9	146.8698	1716.5407
10	134.5652	1440.9668	10	147.1316	1722.6634
11	134.8270	1446.5802	11	147.3934	1728.8995

TABLE XII,

Containing the squares, cubes, superficies, and solid content of spheres, from ⅛ inch to 12 inches, advancing by an eighth.

Diam.	Squares.	Cubes.	Superficies.	Solidity.
⅛	.25	.125	.7854	.0654
⅛	.390625	.244140625	1.2271	.1278
¼	.5625	.421875	1.7671	.2208
⅞	.765625	.669921875	2.4052	.3507
1 *in.*	1	1	3.1416	.5236
⅛	1.265625	1.423818125	3.9760	.7455
¼	1.5625	1.953125	4.9087	1.0226
⅜	1.890625	2.599609375	5.9395	1.3611
½	2.25	3.375	7.0686	1.7671
⅝	2.640625	4.291015625	8.2957	2.2467
¾	3.0625	5.359375	9.6211	2.8061
⅞	3.515625	6.591796875	11.0446	3.4514
2 *in.*	4	8	12.5664	4.1888
⅛	4.515625	9.595703125	14.1862	5.0243
¼	5.0625	11.390625	15.9043	5.9640
⅜	5.640625	13.39648375	17.7205	7.0143
½	6.25	15.625	19.6350	8.1812
⅝	6.890625	18.087890625	21.6475	9.4708
¾	7.5625	20.796875	23.7583	10.8892
⅞	8.265625	23.763671875	25.9672	12.4426
3 *in.*	9	27	28.2744	14.1372
⅛	9.765625	30.517578125	30.6796	15.9790
¼	10.5625	34.328125	33.1831	17.9742
⅜	11.390625	38.443359375	35.7847	20.1289
½	12.25	42.875	38.4846	22.4493
⅝	13.140625	47.634765625	41.2825	24.9415
¾	14.0625	52.734375	44.1787	27.6117
⅞	15.015625	58.185546875	47.1730	30.4659
4 *in.*	16	64	50.2656	33.5104
⅛	17.015625	70.189453125	53.4562	36.7511
¼	18.0625	76.765625	56.7451	40.1944
⅜	19.140625	83.740234375	60.1321	43.8463
½	20.25	91.125	63.6174	47.7127
⅝	21.390625	98.931640625	67.2007	51.8006
¾	22.5625	107.171875	70.8823	56.1151
⅞	23.765625	115.857421875	74.6629	60.6629
5 *in.*	251	125	78.5400	65.4500
⅛	26.265625	134.611328125	82.5160	70.4824
¼	27.5625	144.703125	86.5903	75.7664
⅜	28.890625	155.287109375	90.7627	81.3083
½	30.25	166.375	95.0334	87.1139
⅝	31.640625	177.978515625	99.4021	93.1875
¾	33.0625	190.109375	103.8691	99.5412
⅞	34.515625	202.779296875	108.4342	106.1754

Diam.	Superficies.	Solidity.	Diam.	Superficies.	Solidity.
4.0	50.2656	33.5104	8.0	201.0624	268.0832
.1	52.8102	36.0870	.1	206.1203	278.2925
.2	55.4178	38.7924	.2	211.2411	288.6962
.3	58.0881	41.6298	.3	216.4248	299.3876
.4	60.8213	44.6023	.4	221.6712	310.3393
.5	63.6174	47.7130	.5	226.9806	321.5553
.6	66.4762	50.9651	.6	232.3527	333.0389
.7	69.3979	54.3617	.7	237.7877	344.7921
.8	72.3824	57.9059	.8	243.2855	356.8187
.9	75.4298	61.6010	.9	248.8461	369.1217
5.0	78.5400	65.4500	9.0	254.4696	381.7044
.1	81.7130	69.4560	.1	260.1558	394.5697
.2	84.9488	73.6223	.2	265.9130	407.7210
.3	88.2475	77.9519	.3	271.7169	421.1613
.4	91.6090	82.4481	.4	277.5917	434.8937
.5	95.0334	87.1139	.5	283.5294	448.9215
.6	98.5205	91.9525	.6	289.5298	463.2477
.7	102.0705	96.9670	.7	295.5931	477.7755
.8	105.6834	102.1606	.8	301.7192	492.6081
.9	109.3590	107.5364	.9	307.9082	508.0485
6.0	113.0976	113.0976	10.0	314.1600	523.6000
.1	116.8989	118.8472	.1	320.4746	539.4656
.2	120.7631	124.7885	.2	326.8520	555.6485
.3	124.6901	130.9246	.3	333.2923	572.1518
.4	128.6799	137.2585	.4	339.7954	588.9784
.5	132.7326	143.7936	.5	346.3614	606.1324
.6	136.8480	150.5329	.6	352.9901	623.6159
.7	141.0264	157.4795	.7	359.6817	641.4325
.8	145.2675	164.6365	.8	366.4362	659.5852
.9	149.5715	172.0073	.9	373.2534	678.0771
7.0	153.9384	179.5948	11.0	380.1336	696.9116
.1	158.3680	187.4021	.1	387.0765	716.0915
.2	162.8605	195.4326	.2	394.0823	735.6209
.3	167.4158	203.6893	.3	401.1509	755.5008
.4	172.0340	212.1752	.4	408.2823	775.7364
.5	176.7150	220.8937	.5	415.4766	796.3291
.6	181.4588	229.8478	.6	422.7336	817.2801
.7	186.2654	239.0511	.7	430.0536	838.6045
.8	191.1349	248.4754	.8	437.4363	860.2915
.9	196.0672	258.1552	.9	444.8819	882.3492
			12.0	452.3904	904.7808

TABLE

Containing the price of metals, or other materials, by the hundred, quarter, or lb.

Per cwt.			Per qrtr.			Per lb.			Per cwt.			Per qrtr.			Per lb.			Per cwt.			Per qrtr.			Per lb.		
£	s.	d.	s.	d.		£	s.	d.	£	s.	d.	s.	d.		£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
2	6	8	2	4					24	0	0	6	0		32	10	0	1	12	6	0	8	1			
2	10	0	2	6	0	0	2	1	24	15	0	6	0	0	32	13	4	1	13	6	0	8	1	0	0	3
2	13	4	2	9	0	0	2	2	25	0	0	6	0	0	33	0	0	1	13	6	0	8	2			
2	16	8	2	9	0	0	2	2	25	5	0	6	0	0	33	6	8	1	13	6	0	8	2	0	0	3
3	0	0	3	0	0	0	2	3	25	10	0	6	0	0	33	10	0	1	13	6	0	8	2	0	0	3
3	3	4	3	3	0	0	2	3	25	15	0	6	0	0	33	13	4	1	13	6	0	8	3			
3	6	8	3	3	0	0	2	3	26	0	0	6	0	0	33	16	8	1	13	6	0	8	3	0	0	3
3	10	0	3	6	0	0	2	3	26	5	0	6	0	0	34	0	0	1	14	0	0	8	3			
3	13	4	3	6	0	0	2	3	26	10	0	6	0	0	34	6	8	1	14	0	0	8	3	0	0	3
3	16	8	3	9	0	0	2	3	26	15	0	6	0	0	34	13	4	1	14	0	0	8	4			
4	0	0	4	0	0	0	2	4	27	0	0	6	0	0	35	0	0	1	14	0	0	8	4	0	0	4
4	3	4	4	0	0	0	2	4	27	5	0	6	0	0	35	6	8	1	14	0	0	8	4			
4	6	8	4	3	0	0	2	4	27	10	0	6	0	0	35	13	4	1	14	0	0	8	4	0	0	4
4	10	0	4	3	0	0	2	4	27	15	0	6	0	0	35	16	8	1	14	0	0	8	5			
4	13	4	4	3	0	0	2	4	28	0	0	6	0	0	36	0	0	1	14	0	0	8	5	0	0	4
4	16	8	4	6	0	0	2	4	28	5	0	6	0	0	36	6	8	1	14	0	0	8	5			
5	0	0	4	6	0	0	2	4	28	10	0	6	0	0	36	13	4	1	14	0	0	8	5	0	0	4
5	3	4	4	6	0	0	2	4	28	15	0	6	0	0	36	16	8	1	14	0	0	8	6			
5	6	8	4	9	0	0	2	4	29	0	0	6	0	0	37	0	0	1	14	0	0	8	6	0	0	4
5	10	0	4	9	0	0	2	4	29	5	0	6	0	0	37	6	8	1	14	0	0	8	6			
5	13	4	4	9	0	0	2	4	29	10	0	6	0	0	37	13	4	1	14	0	0	8	6	0	0	4
5	16	8	5	0	0	0	2	5	29	15	0	6	0	0	37	16	8	1	14	0	0	8	7			
6	0	0	5	0	0	0	2	5	30	0	0	6	0	0	38	0	0	1	14	0	0	8	7	0	0	4
6	3	4	5	3	0	0	2	5	30	5	0	6	0	0	38	6	8	1	14	0	0	8	7			
6	6	8	5	3	0	0	2	5	30	10	0	6	0	0	38	13	4	1	14	0	0	8	7	0	0	4
6	10	0	5	6	0	0	2	5	30	15	0	6	0	0	38	16	8	1	14	0	0	8	8			
6	13	4	5	6	0	0	2	5	31	0	0	6	0	0	39	0	0	1	14	0	0	8	8	0	0	4
6	16	8	5	9	0	0	2	5	31	5	0	6	0	0	39	6	8	1	14	0	0	8	8			
7	0	0	6	0	0	0	2	6	31	10	0	6	0	0	39	13	4	1	14	0	0	8	8	0	0	4
7	3	4	6	0	0	0	2	6	31	15	0	6	0	0	39	16	8	1	14	0	0	8	9			
7	6	8	6	3	0	0	2	6	32	0	0	6	0	0	40	0	0	2	0	0	0	10	0			
7	10	0	6	3	0	0	2	6	32	5	0	6	0	0	40	10	0	2	0	6	0	10	1	0	0	4
7	13	4	6	6	0	0	2	6	32	10	0	6	0	0	41	0	0	2	1	0	0	10	3			
7	16	8	6	6	0	0	2	6	32	15	0	6	0	0	41	10	0	2	1	6	0	10	4	0	0	4
8	0	0	6	9	0	0	2	6	33	0	0	6	0	0	42	0	0	2	2	0	0	10	6			
8	3	4	6	9	0	0	2	6	33	5	0	6	0	0	42	10	0	2	2	6	0	11	0	0	0	4
8	6	8	7	0	0	0	2	7	33	10	0	6	0	0	43	0	0	2	3	0	0	11	1			
8	10	0	7	0	0	0	2	7	33	15	0	6	0	0	43	10	0	2	3	6	0	11	2	0	0	4
8	13	4	7	0	0	0	2	7	34	0	0	6	0	0	44	0	0	2	4	0	0	11	3			
8	16	8	7	3	0	0	2	7	34	5	0	6	0	0	44	10	0	2	4	6	0	11	4	0	0	4
9	0	0	7	3	0	0	2	7	34	10	0	6	0	0	45	0	0	2	5	0	0	11	5			
9	3	4	7	3	0	0	2	7	34	15	0	6	0	0	45	10	0	2	5	6	0	11	6	0	0	4
9	6	8	7	6	0	0	2	7	35	0	0	6	0	0	46	0	0	2	6	0	0	11	7			
9	10	0	7	6	0	0	2	7	35	5	0	6	0	0	46	10	0	2	6	6	0	11	8	0	0	4
9	13	4	7	6	0	0	2	7	35	10	0	6	0	0	47	0	0	2	7	0	0	11	9			
9	16	8	7	9	0	0	2	7	35	15	0	6	0	0	47	10	0	2	7	6	0	11	10	0	0	4
10	0	0	7	9	0	0	2	7	36	0	0	6	0	0	48	0	0	2	8	0	0	11	11			
10	3	4	7	9	0	0	2	7	36	5	0	6	0	0	48	10	0	2	8	6	0	12	0	0	0	4
10	6	8	8	0	0	0	2	8	36	10	0	6	0	0	49	0	0	2	9	0	0	12	1			
10	10	0	8	0	0	0	2	8	36	15	0	6	0	0	49	10	0	2	9	6	0	12	2	0	0	4
10	13	4	8	0	0	0	2	8	37	0	0	6	0	0	50	0	0	2	10	0	0	12	3			
10	16	8	8	3	0	0	2	8	37	5	0	6	0	0	50	10	0	2	10	6	0	12	4	0	0	4
11	0	0	8	3	0	0	2	8	37	10	0	6	0	0	51	0	0	2	11	0	0	12	5			
11	3	4	8	3	0	0	2	8	37	15	0	6	0	0	51	10	0	2	11	6	0	12	6	0	0	4
11	6	8	8	6	0	0	2	8	38	0	0	6	0	0	52	0	0	3	0	0	0	13	0			
11	10	0	8	6	0	0	2	8	38	5	0	6	0	0	52	10	0	3	0	6	0	13	1	0	0	4
11	13	4	8	6	0	0	2	8	38	10	0	6	0	0	53	0	0	3	1	0	0	13	2			
11	16	8	8	9	0	0	2	8	38	15	0	6	0	0	53	10	0	3	1	6	0	13	3	0	0	4
12	0	0	8	9	0	0	2	8	39	0	0	6	0	0	54	0	0	3	2	0	0	13	4			
12	5	0	8	9	0	0	2	8	39	5	0	6	0	0	54	10	0	3	2	6	0	13	5	0	0	4
12	10	0	8	9	0	0	2	8	39	10	0	6	0	0	55	0	0	3	3	0	0	13	6			
12	15	0	8	9	0	0	2	8	39	15	0	6	0	0	55	10	0	3	3	6	0	13	7	0	0	4
13	0	0	9	0	0	0	2	9	40	0	0	6	0	0	56	0	0	3	4	0	0	13	8			
13	5	0	9	0	0	0	2	9	40	5	0	6	0	0	56	10	0	3	4	6	0	13	9	0	0	4
13	10	0	9	0	0	0	2	9	40	10	0	6	0	0	57	0	0	3	5	0	0	13	10			
13	15	0	9	0	0	0	2	9	40	15	0	6	0	0	57	10	0	3	5	6	0	13	11	0	0	4
14	0	0	9	0	0	0	2	9	41	0	0	6	0	0	58	0	0	3	6	0	0	14	0			
14	5	0	9	3	0	0	2	9	41	5	0	6	0	0	58	10	0	3	6	6	0	14	1	0	0	4
14	10	0	9	3	0	0	2	9	41	10	0	6	0	0	59	0	0	3	7	0	0	14	2			
14	15	0	9	3	0	0	2	9	41	15	0	6	0	0	59	10	0	3	7	6	0	14	3	0	0	4
15	0	0	9	6	0	0	2	9	42	0	0	6	0	0	60	0	0	3	8	0	0	14	4			
15	5	0	9	6	0	0	2	9	42	5	0	6	0	0	60	10	0	3	8	6	0	14	5	0	0	4
15	10	0	9	6	0	0	2	9	42	10	0	6	0	0	61	0	0	3	9	0	0	14	6			
15	15	0	9	6	0	0	2	9	42	15	0	6	0	0	61	10	0	3	9	6	0	14	7	0	0	4
16	0	0	9	9	0	0	2	9	43	0	0	6	0	0	62	0	0	3	10	0	0	14	8			
16	5	0	9	9	0	0	2	9	43	5	0	6	0	0	62	10	0	3	10	6	0	14	9	0	0	4
16	10	0	9	9	0	0	2	9	43	10	0	6	0	0	63	0	0	3	11	0	0	14	10			
16	15	0	9	9	0	0	2	9	43	15	0	6	0	0	63	10	0	3	11	6	0	14	11	0	0	4
17	0	0	10	0	0	0	2	10	44	0	0	6	0	0	64	0	0	4	0	0	0	15	0			
17	5	0	10	0	0	0	2	10	44	5	0	6	0	0	64	10	0	4	0	6	0	15	1	0	0	4
17	10	0	10	0	0	0	2	10	44	10	0	6	0	0	65	0	0	4	1	0	0	15	2			
17	15	0	10	0	0	0	2	10	44	15	0	6	0	0	65	10	0	4	1	6	0	15	3	0	0	4
18	0	0	10	3	0	0	2	10	45	0	0	6	0	0	66	0	0	4	2	0	0	15	4			
18	5	0	10	3	0	0	2	10	45	5	0	6	0	0	66	10	0	4	2	6	0	15	5	0	0	4
18	10	0	10	3	0	0	2	10	45	10	0	6	0	0	67	0	0	4	3	0	0	15	6			
18	15	0	10	3	0	0	2	10	45	15	0	6	0	0	67	10	0	4	3	6	0	15	7	0	0	4
19	0	0	10	6	0	0	2	10	46	0	0	6	0	0	68	0	0	4	4	0	0	15	8			
19	5	0	10	6	0	0	2	10	46	5	0	6	0	0	68	10	0	4	4	6	0	15	9	0	0	4
19	10	0	10	6	0	0	2	10	46	10	0	6	0	0	69	0	0	4	5	0	0	15	10			
19	15	0	10	6	0	0	2	10	46	15	0	6	0	0	69	10	0	4	5	6	0	15	11	0	0	4
20	0	0	10	9	0	0	2	10	47	0	0	6	0	0	70	0	0	4	6	0	0	16	0			
20	5	0	10	9	0	0	2	10	47	5	0	6	0	0	70	10	0	4	6	6	0	16	1	0	0	4
20	10	0	10	9	0	0	2	10	47	10	0	6	0	0	71	0	0	4	7	0	0	16	2			
20	15	0	10	9	0	0	2	10	47	15	0	6	0	0	71	10	0	4	7	6	0	16	3	0	0	4
21	0	0	11	0	0	0	2	11	48	0	0	6	0	0	72	0	0	4	8	0	0	16	4			
21	5	0	11	0	0	0	2	11	48	5	0	6	0	0	72	10	0	4	8	6	0	16	5	0	0	4
21	10	0	11	0	0	0	2	11	48	10	0	6	0	0	73	0	0	4	9	0	0	16	6			
21	15	0	11	0	0	0	2	11	48	15	0	6	0	0	73	10	0	4	9	6	0	16	7	0	0	4
22	0	0	11	3	0	0	2	11	49	0	0	6	0	0	74	0	0	4	10	0	0	16	8			
22	5	0	11	3	0	0	2	11	49	5	0	6	0	0	74	10	0	4	10	6	0	16	9	0	0	4
22	10	0	11	3	0	0	2	11	49	10	0	6	0	0	75	0	0	4	11	0	0	16	10			
22	15	0	11	3	0	0	2	11	49	15	0	6	0	0	75	10	0	4	11	6	0	16	11	0	0	4
23	0	0	11	6	0	0	2	11	50	0	0	6	0	0	76	0	0	5	0	0	0	17	0			
23	5	0	11	6	0	0	2	11	50	5	0	6	0	0	76	10	0	5	0	6	0	17	1	0	0	4
23	10	0	11	6	0	0	2	11	50	10	0	6	0	0	77	0	0	5	1	0	0	17	2			
23	15	0	11	6	0	0	2	11	50	15	0	6	0	0	77	10	0	5	1	6	0	17	3	0	0	4
24	0	0	11	9	0	0	2	11	51	0	0	6	0	0	78	0	0	5	2	0	0	17	4			
24	5	0	11	9	0	0	2	11	51	5	0	6	0	0	78	10	0	5	2	6	0	17	5	0	0	4
24	10	0	11	9	0	0	2	11	51	10	0	6	0	0	79	0	0	5	3	0	0	17	6			
24	15	0	11	9	0	0	2	11	51	15	0	6	0	0	79	10	0	5	3	6	0	17	7	0	0	4
25	0	0	12	0	0	0	3	0	52	0	0	6	0	0	80	0	0	5	4	0	0	17	8			
25	5	0	12	0	0	0	3	0	52	5	0	6	0	0	80	10	0	5	4	6	0	17	9	0	0	4
25	10	0	12	0	0	0	3	0	52	10	0	6	0	0	81	0	0	5	5	0	0	17	10			
25	15	0	12	0	0	0	3	0	52	15	0	6	0	0	81	10	0	5	5	6	0	17	11	0	0	4
26	0	0	12	3	0	0	3	0	53	0	0	6	0	0	82	0	0	5	6	0	0	18	0			
26	5	0	12	3	0	0	3	0	53	5	0	6	0	0	82	10	0	5	6	6	0	18	1	0	0	4
26	10	0	12	3	0	0	3	0	53	10	0	6	0	0	83	0	0	5	7	0	0	18	2			
26	15	0	12	3	0	0	3	0	53	15	0	6	0	0	83	10	0	5	7	6	0	18	3	0	0	4
27	0	0	12	6	0	0	3	1	54	0	0	6	0	0	84	0	0	5	8	0	0	18	4			
27	5	0	12	6	0	0	3	1	54	5	0	6	0	0	84	10	0	5	8	6	0	18	5	0	0	4
27	10	0	12	6	0	0	3	1	54	10	0	6	0	0	85	0	0	5	9	0	0	18	6			
27	15	0	12	6	0	0	3	1	54	15	0	6	0	0	85	10	0	5	9	6	0	18	7	0	0	4
28	0	0	12	9	0	0	3	1	55	0	0	6	0	0	86	0	0	5	10	0	0	18	8			
28	5	0	12	9	0	0	3	1	55	5	0	6	0	0	86	10	0	5	10	6	0	18	9	0	0	4
28	10	0	12	9	0	0	3	1	55	10	0	6	0	0	87	0	0	5	11	0	0	18	10			
28	15	0	12	9	0	0	3	1	55	15	0	6	0	0	87	10	0	5	11	6	0	18	11	0	0	4
29	0	0	13	0	0	0	3	2	56	0	0	7	0	0	88	0	0	6	0	0	0	19	0			
29	5	0	13	0	0	0	3	2	56	5	0	7	0	0	88	10	0	6	0	6	0	19	1	0	0	4
29	10	0	13	0	0	0	3	2	56	10	0	7	0	0	89	0	0	6	1	0	0	19	2			
29	15	0	13	0	0	0	3	2	56	15	0	7	0	0	89	10	0	6	1	6	0	19	3	0	0	4
30	0	0	13	3	0	0	3	3	57	0	0	7	1	0	90	0	0	6	2	0	0	19	4			
30	5	0	13	3	0	0	3	3	57	5	0	7	1	0	90	10	0	6	2	6	0	19	5	0	0	4
30	10	0	13	3	0	0	3	3	57	10	0	7	1	0	91	0	0	6	3	0	0	19	6			
30	15	0	13	3	0	0	3	3	57	15	0	7	1	0	91	10	0	6	3	6	0	19	7	0	0	4
31	0	0	13	6	0	0	3	4	58	0	0	7	1	0	92	0	0	6	4	0	0	19	8			
31	5	0	13	6	0	0	3	4	58	5	0	7	1	0	92	10	0	6	4	6	0	19	9	0	0	4
31	10	0	13	6	0	0	3	4	58	10	0	7	1	0	93	0	0	6	5	0	0	19	10			
31	15	0	13	6	0	0	3	4	58	15	0	7	1	0	93	10	0	6	5	6	0	19	11	0	0	4
32	0	0	13	9	0	0	3	5	59	0	0	7	1	0	94	0	0	6	6	0	0	20	0			
32	5	0	13	9	0	0	3	5	59	5	0	7	1	0	94	10	0	6	6	6	0	20	1	0	0	4
32	10	0	13	9	0	0	3	5	59	10	0	7	1	0	95	0	0	6	7	0	0	20	2			
32	15	0	13	9	0	0	3	5	59	15	0	7	1	0	95	10	0	6	7	6	0	20	3	0	0	4
33	0	0	14	0	0	0	3	6	60	0	0	7	1	0	96	0	0	6	8	0	0	20	4			
33	5	0	14	0	0	0	3	6	60	5	0	7	1	0	96	10	0	6	8	6	0	20	5	0	0	4
33	10	0	14	0	0	0	3	6	60	10	0	7	1	0	97	0	0	6	9	0	0	20	6			
33	15	0	14	0	0	0	3	6	60	15	0	7	1	0	97	10	0	6	9	6	0	20	7	0	0	4
34	0	0	14	3	0	0	3	6	61	0	0	7	1	0	98	0	0	6	10	0	0	20	8			
34	5	0	14	3	0	0	3	6	61	5	0	7	1	0	98	10	0	6	10	6	0	20	9	0	0	4
34	10	0	14	3	0	0	3	6	61	10	0	7	1	0	99	0	0	6	11	0	0	20	10	

Diam.	*Squares.*	*Cubes.*	*Superficies.*	*Solidity.*
6 *in.*	36	216	113.0976	113.0976
⅛	37.515625	229.783203115	117.8590	120.3139
¼	39.0625	244.140625	122.7187	127.8320
⅜	40.640625	259.083984375	127.6765	135.6563
½	42.25	274.625	132.7326	143.7936
⅝	43.890625	290.775390625	137.8867	152.2499
¾	45.5625	307.546875	143.1391	161.0315
⅞	47.265625	324.951171875	148.4896	170.1682
7 *in.*	49	343	153.9384	179.5948
⅛	50.765625	361.704078125	159.4852	189.3882
¼	52.5625	381.078125	165.1303	199.5325
⅜	54.390625	401.130859375	170.8735	210.0331
½	56.25	421.875	176.7150	220.8937
⅝	58.140625	443.322265625	182.6545	232.1235
¾	60.0625	465.484375	188.6923	243.7276
⅞	62.015625	488.373046875	194.8282	255.7121
8 *in.*	64	512	201.0624	268.0832
⅛	66.015625	536.376953125	207.3946	280.8469
¼	68.0625	561.515625	213.8251	294.0095
⅜	70.140625	587.427734375	220.3537	307.5771
½	72.25	614.125	226.9806	321.5553
⅝	74.390625	641.619140625	233.7055	335.9517
¾	76.5625	669.921875	240.5287	350.7710
⅞	78.765625	699.044921875	247.4500	366.0199
9 *in.*	81	729	254.4696	381.7017
⅛	83.265625	759.798828125	261.5872	397.8306
¼	85.5625	791.453125	268.8031	414.4048
⅜	87.890625	823.974609375	276.1171	431.4361
½	90.25	857.375	283.5294	448.9215
⅝	92.640625	891.666015625	291.0397	466.8763
¾	95.0625	926.859375	298.6483	485.3035
⅞	97.515625	962.966796875	306.3550	504.2094
10 *in.*	100	1000	314.1600	523.6000
⅛	102.515625	1037.970703125	322.0630	543.4814
¼	105.0625	1076.890625	330.0643	563.8603
⅜	107.640625	1116.771448375	338.1637	584.7415
½	110.25	1157.625	346.3614	606.1318
⅝	112.890625	1199.462890625	354.6571	628.0387
¾	115.5625	1242.296875	363.0511	650.4666
⅞	118.265625	1286.138671875	371.5432	673.4222
11 *in.*	121	1331	380.1336	696.9116
⅛	123.765625	1376.892578125	388.8220	720.9409
¼	126.5625	1423.828125	397.6087	745.5004
⅜	129.390625	1471.818359375	406.4935	770.6440
½	132.25	1520.875	415.4766	796.3301
⅝	135.140625	1571.009765625	424.5576	822.5867
¾	138.0625	1622.234375	433.7371	849.4035
⅞	141.015625	1674.560546875	443.0145	876.7909
12 *in.*	144	1728	452.3904	904.7802

NOTE.—For 2 per cent. take the half of 4, and 2½ per cent. the half of 5.

RULE.—Multiply the principle by the number of days, and take the interest corresponding to the product from the marginal column.

EXAMPLE.—Suppose £375 for 144 days, at 3 per cent.

$$375 \times 144 = 54{,}000.$$

By table—50,000 =	£4	2	2.30
4,000 =	0	6	6.90
Interest..	£4	8	9.20

Table of discount per cent.

	s.	d.		s.	d.
2½ per cent. is	0	6 per £	9 per cent. is	1	9½ per £
3 „	0	7¼	9½ „	1	10¾
3½ „	0	8½	10 „	2	0
4 „	0	9½	10½ „	2	1¼
4½ „	0	10¾	12½ „	2	6
5 „	1	0	15 „	3	0
5½ „	1	1¼	17½ „	3	7
6 „	1	2½	20 „	4	0
6½ „	1	3¾	22½ „	4	6
7 „	1	5	25 „	5	0
7½ „	1	6	30 „	6	0
8 „	1	7	35 „	7	0
8½ „	1	8½	40 „	8	0

Printed by Egerton Smith and Co., Lord-street, Liverpool.

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L.

MATHEMATICAL TABLES

FOR

PRACTICAL MEN;

COMPRISING

EXTENSIVE TABLES OF CIRCUMFERENCES;

SQUARES, CUBES, AND AREAS OF CIRCLES;

SQUARE AND CUBE ROOTS OF NUMBERS,

WITH THEIR DIFFERENCES, FOR FACILITATING

FRACTIONAL CALCULATIONS;

SUPERFICIES AND SOLIDITIES OF SPHERES,

&c. &c.

WITH OTHER USEFUL TABLES, EQUALLY ADAPTED TO PRACTICAL PURPOSES.

BY WILLIAM TEMPLETON,

Author of "The Millwright and Engineer's Pocket Companion," "The Engineer's Common-place Book," &c. &c.

LONDON:

PUBLISHED BY SIMPKIN, MARSHALL, AND CO., STATIONERS'-HALL-COURT; SOLD ALSO BY G. HEBERT, 68, CHEAPSIDE, LONDON; EGERTON SMITH AND CO., LIVERPOOL; J. AND J. THOMSON, MANCHESTER; W. CURRY, JUN., AND CO., DUBLIN; BLACK AND CO., EDINBURGH; AND BY ALL BOOKSELLERS.

1841.

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
6 *in.*	18.8496	36	216	28.2744	5.3172
1/16	19.0459	36.7539	222.8205	28.8665	5.3725
1/8	19.2423	37.5156	229.7832	29.4647	5.4280
3/16	19.4386	38.2851	236.8890	30.0798	5.4834
1/4	19.6350	39.0625	244.1406	30.6796	5.5388
5/16	19.8313	39.8476	249.2654	31.2964	5.5942
3/8	20.0277	40.6406	259.0839	31.9192	5.6495
7/16	20.2240	41.4414	256.7605	32.5481	5.7049
1/2	20.4204	42.25	274.625	33.1831	5.7603
9/16	20.6167	43.0664	282.6232	33.8244	5.8157
5/8	20.8131	43.8906	290.7753	34.4717	5.8711
11/16	21.0094	44.7226	299.0823	35.1252	5.9265
3/4	21.2058	45.5625	307.5468	35.7847	5.9819
13/16	21.4021	46.4101	316.1688	36.4505	6.0373
7/8	21.5985	47.2656	324.9511	37.1224	6.0927
15/16	21.7948	48.1289	333.8943	37.8005	6.1480
7 *in.*	21.9912	49	343	38.4846	6.2034
1/16	22.1875	49.8789	349.5702	39.1749	6.2588
1/8	22.3839	50.7656	361.7040	39.8713	6.3142
3/16	22.5802	51.6601	371.3070	40.5469	6.3696
1/4	22.7766	52.5625	381.0781	41.2825	6.4350
5/16	22.9729	53.4726	391.0184	41.9974	6.4904
3/8	23.1693	54.3906	401.1308	42.7184	6.5358
7/16	23.3656	55.3164	411.4158	43.4455	6.5912
1/2	23.5620	56.25	421.875	44.1787	6.6465
9/16	23.7583	57.1914	432.5100	44.9181	6.7020
5/8	23.9547	58.1406	443.3222	45.6636	6.7573
11/16	24.1510	59.0976	454.3129	46.4153	6.8127
3/4	24.3474	60.0625	465.4843	47.1730	6.8681
13/16	24.5437	61.0351	476.8368	47.9370	6.9235
7/8	24.7401	62.0156	488.3730	48.7070	6.9789
15/16	24.9364	63.0039	500.0935	49.4833	7.0343
8 *in.*	25.1328	64	512	50.2656	7.0897
1/16	25.3291	65.0039	524.1939	51.0541	7.1451
1/8	25.5255	66.0156	536.3769	51.8486	7.2005
3/16	25.7218	67.0351	548.8499	52.8994	7.2559
1/4	25.9182	68.0625	561.5156	53.4562	7.3112
5/16	26.1145	69.0976	574.3739	54.2748	7.3666
3/8	26.3109	70.1406	587.4277	55.0885	7.4220
7/16	26.5072	71.1914	600.6775	55.9138	7.4774
1/2	26.7036	72.25	614.125	56.7451	7.5328
9/16	26.8999	73.3164	627.7717	57.5887	7.5882
5/8	27.0963	74.3906	641.6191	58.4264	7.6436
11/16	27.2926	75.4726	655.6683	59.7762	7.6990
3/4	27.4890	76.	669.9210	60.1321	7.7544
13/16		77.	684.3797	60.9943	7.8098
7/8			699.0449	61.8625	7.8652
15/16			713.9177	62.7369	7.9206

PREFACE.

The object of the following pages is the facilitating of numerous calculations which the practical man constantly requires in his daily avocations, and in which accuracy and a saving of time is of essential benefit,—hence their utility.

Few men in active business, and where calculations are generally in greatest demand, can devote much of their time to that unavoidable department; hence the inestimable value of accurate mathematical tables, not only for the benefit of despatch, but as the means by which complex and difficult calculations are easily and confidently surmounted.

The author being aware of this, not only from individual daily practice, but by pressing solicitations, was induced to undertake the arduous task of constructing the following tables, no little part of which task was the selecting of those containing the greatest public interest, the number and variety which might be individually useful being almost unlimited; and to attempt a work generally applicable to each distinct department, would, in fact, be the means of rendering the same of *comparatively little* use or value to any. Many, having

occasion for a work of the kind, would not purchase a large book, partly on account of its being too voluminous for constant reference, and partly on account of having to purchase, for the sake of a small portion of the work, that which they might seldom or never require. With this view the author relinquished the idea of a large work, and gave way to one, though smaller, yet far more extensively useful.

It may be thought, however, that, to render the work generally useful, some further explanation to each table ought to be attached; but this was considered by the author to be superfluous, as the greater portion of the tables will be found so explicit as to require no farther illustration or comment than the titles they bear; to the others, which it was supposed might require some little elucidation, rules and examples are added, sufficient for the purpose of attaining a competent knowledge and use of the table.

It may now only be necessary to add, as the author was aware that the real value of mathematical tables depends entirely upon their accuracy, no pains or time was spared to gain this grand point, therefore it is anticipated this work will not only be found accurate, but exceedingly useful, and well suited to the demands of engineers, mechanics, and the public in general.

Leeds, August, 1841.

A TABLE

CONTAINING THE

CIRCUMFERENCES, SQUARES, CUBES,

AND

AREAS OF CIRCLES,

From $\frac{1}{12}$*th to* 100 *inches, advancing by a* $\frac{1}{12}$*th, and also the side of equal square, advancing at an equal ratio.*

NOTE.—For 2 per cent. take the half of 4, and 2½ the half of 5.

RULE.—Multiply the principle by the number of days, and take the interest corresponding to the product from the marginal column.

EXAMPLE.—Suppose £375 for 144 days, at 4 per cent.

$$375 \times 144 = 54{,}000.$$

By table—50,000 =	£4	2	2.30
4,000 =	0	6	6.90
Interest..	£4	8	9.20

Table of discount per cent.

	s.	d.		s.	d.
2½ per cent. is	0	6 per £	9 per cent. is	1	9½ per £
3 „	0	7¼	9½ „	1	10¾
3½ „	0	8½	10 „	2	0
4 „	0	9½	10½ „	2	1¼
4½ „	0	10¾	12½ „	2	6
5 „	1	0	15 „	3	0
5½ „	1	1¼	17½ „	3	7
6 „	1	2½	20 „	4	0
6½ „	1	3½	22½ „	4	6
7 „	1	5	25 „	5	0
7½ „	1	6	30 „	6	0
8 „	1	7	35 „	7	0
8½ „	1	8½	40 „	8	0

Printed by Egerton Smith and Co., Lord street, Liverpool.

Square.	Cube.	Area.	Side of = square.
441	9261	346.3614	18.6102
443.6289	9343.933	348.4267	18.6656
446.2656	9427.360	350.4970	18.7210
448.9101	9511.282	352.5740	18.7764
451.5625	9595.703	354.6571	18.8318
454.2228	9680.617	356.7465	18.8872
456.8909	9766.036	358.8419	18.9425
459.5669	9853.954	360.9435	18.9979
462.25	9938.375	363.0511	19.0533
464.9411	10025.29	365.1650	19.1087
467.6400	10112.72	367.2849	19.1641
470.3476	10200.66	369.4110	19.2195
473.0625	10289.11	371.5432	19.2749
475.7851	10378.06	373.6816	19.3303
478.5156	10467.52	375.8261	19.3857
481.2540	10557.54	377.9768	19.4410
484	10648	380.1336	19.4964
486.7539	10739.00	382.2965	19.5518
489.5156	10830.53	384.4655	19.6072
492.2852	10922.57	386.6907	19.6626
495.0625	11015.14	388.8220	19.7180
497.8476	11108.22	391.0095	19.7734
500.6406	11201.83	393.2031	19.8287
503.4414	11295.96	395.4029	19.8841
506.25	11390.62	397.6087	19.9395
509.0664	11485.81	399.8207	19.9949
511.8906	11581.52	402.0388	20.0503
514.7226	11677.76	404.2631	20.1057
517.5625	11774.54	406.4935	20.1611
520.4102	11871.85	408.7301	20.2165
523.2656	11969.70	410.9728	20.2719
526.1289	12068.08	413.2317	20.3272
529	12167	415.4766	20.3826
531.8789	12266.45	417.7377	20.4380
534.7656	12366.45	420.0049	20.4934
537.6602	12466.99	422.2783	20.5490
540.5625	12568.07	424.5577	20.6042
543.4727	12669.70	426.8434	20.6596
546.3906	12771.88	429.1352	20.7150
549.3164	12874.60	431.4331	20.7703
552.25	12977.87	433.7371	20.8257
555.1914	13081.69	436.0473	20.8811
558.1406	13186.08	438.3636	20.9365
561.0977	13291.03	440.6811	20.9919
564.0625	13396.48	443.0146	21.0473
567.0352	13502.52	445.3539	21.1027
570.0156	13609.13	447.6992	21.1581
573.0039	13716.33	450.0418	21.2134

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
6 *in.*	18.8496	36	216	28.2744	5.3172
1/16	19.0459	36.7539	222.8205	28.8665	5.3726
1/8	19.2423	37.5156	229.7832	29.4647	5.4280
3/16	19.4386	38.2851	236.8890	30.0798	5.4834
1/4	19.6350	39.0625	244.1406	30.6796	5.5388
5/16	19.8313	39.8476	249.2654	31.2964	5.5942
3/8	20.0277	40.6406	259.0839	31.9192	5.6495
7/16	20.2240	41.4414	256.7605	32.5481	5.7049
1/2	20.4204	42.25	274.625	33.1831	5.7603
9/16	20.6167	43.0664	282.6232	33.8244	5.8157
5/8	20.8131	43.8906	290.7753	34.4717	5.8711
11/16	21.0094	44.7226	299.0823	35.1252	5.9265
3/4	21.2058	45.5625	307.5468	35.7847	5.9819
13/16	21.4021	46.4101	316.1688	36.4505	6.0373
7/8	21.5985	47.2656	324.9511	37.1224	6.0927
15/16	21.7948	48.1289	333.8943	37.8005	6.1480
7 *in.*	21.9912	49	343	38.4846	6.2034
1/16	22.1875	49.8789	349.5702	39.1749	6.2588
1/8	22.3839	50.7656	361.7040	39.8713	6.3142
3/16	22.5802	51.6601	371.3070	40.5469	6.3696
1/4	22.7766	52.5625	381.0781	41.2825	6.4350
5/16	22.9729	53.4726	391.0184	41.9974	6.4904
3/8	23.1693	54.3906	401.1308	42.7184	6.5358
7/16	23.3656	55.3164	411.4158	43.4455	6.5912
1/2	23.5620	56.25	421.875	44.1787	6.6465
9/16	23.7583	57.1914	432.5100	44.9181	6.7020
5/8	23.9547	58.1406	443.3222	45.6636	6.7573
11/16	24.1510	59.0976	454.3129	46.4153	6.8127
3/4	24.3474	60.0625	465.4843	47.1730	6.8681
13/16	24.5437	61.0351	476.8368	47.9370	6.9235
7/8	24.7401	62.0156	488.3730	48.7070	6.9789
15/16	24.9364	63.0039	500.0935	49.4833	7.0343
8 *in.*	25.1328	64	512	50.2656	7.0897
1/16	25.3291	65.0039	524.1939	51.0541	7.1451
1/8	25.5255	66.0156	536.3769	51.8486	7.2005
3/16	25.7218	67.0351	548.8499	52.8994	7.2559
1/4	25.9182	68.0625	561.5156	53.4562	7.3112
5/16	26.1145	69.0976	574.3739	54.2748	7.3666
3/8	26.3109	70.1406	587.4277	55.0885	7.4220
7/16	26.5072	71.1914	600.6775	55.9138	7.4774
1/2	26.7036	72.25	614.125	56.7451	7.5328
9/16	26.8999	73.3164	627.7717	57.5887	7.5882
5/8	27.0963	74.3906	641.6191	58.4264	7.6436
11/16	27.2926	75.4726	655.6683	59.7762	7.6990
3/4	27.4890	76.5625	669.9218	60.1321	7.7544
13/16	27.6853	77.6601	684.3797	60.9943	7.8098
7/8	27.8817	78.7656	699.0449	61.8625	7.8651
15/16	28.0780	79.8789	713.9177	62.7369	7.9205

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
9 *in.*	28.2744	81	729	63.6174	7.9760
1/16	28.4707	82.1289	744.2932	64.5041	8.0312
1/8	28.6671	83.2656	759.7988	65.3968	8.0866
3/16	28.8634	84.4101	775.5378	66.2957	8.1420
1/4	29.0598	85.5625	791.4531	67.2007	8.1974
5/16	29.2561	86.7226	807.8043	68.1120	8.2527
3/8	29.4525	87.8906	823.9746	69.0293	8.3081
7/16	29.6488	89.0664	840.5642	69.9528	8.3635
1/2	29.8452	90.25	857.375	70.8823	8.4190
9/16	30.0415	91.4414	874.3084	71.8181	8.4743
5/8	30.2379	92.6406	891.6660	72.7599	8.5297
11/16	30.4342	93.8476	909.1487	73.7079	8.5851
3/4	30.6306	95.0625	926.8593	74.6620	8.6405
13/16	30.8269	96.2851	944.7976	75.6223	8.6959
7/8	31.0233	97.5156	962.9667	76.5887	8.7513
15/16	31.2196	98.7539	981.3669	77.5613	8.8066
10 *in.*	31.4160	100	1000	78.5400	8.8620
1/16	31.6123	101.2539	1018.860	79.5248	8.9174
1/8	31.8087	102.5156	1037.970	80.5157	8.9728
3/16	32.0050	103.7851	1057.310	81.5128	9.0282
1/4	32.2014	105.0625	1076.890	82.5160	9.0836
5/16	32.3977	106.3476	1096.709	83.5254	9.1390
3/8	32.5941	107.6406	1116.771	84.5409	9.1943
7/16	32.7904	108.9414	1137.075	85.5626	9.2497
1/2	32.9868	110.25	1157.625	86.5903	9.3051
9/16	33.1831	111.5664	1178.420	87.6243	9.3605
5/8	33.3795	112.8906	1199.462	88.6643	9.4159
11/16	33.5758	114.2226	1220.755	89.7105	9.4713
3/4	33.7722	115.5625	1242.296	90.7627	9.5267
13/16	33.9685	116.9101	1264.090	91.8212	9.5821
7/8	34.1649	118.2656	1286.138	92.8858	9.6375
15/16	34.3612	119.6289	1308.430	93.9566	9.6929
11 *in.*	34.5576	121	1331	95.0334	9.7482
1/16	34.7539	122.3789	1353.816	96.1164	9.8036
1/8	34.9503	123.7656	1376.892	97.2053	9.8590
3/16	35.1466	125.1601	1400.228	98.3008	9.9144
1/4	35.3430	126.5625	1423.828	99.4021	9.9698
5/16	35.5393	127.9726	1447.690	100.5097	10.0252
3/8	35.7357	129.3906	1471.818	101.6234	10.0806
7/16	35.9320	130.8164	1496.412	102.7432	10.1360
1/2	36.1284	132.25	1520.875	103.8691	10.1914
9/16	36.3247	133.6914	1535.796	105.0012	10.2467
5/8	36.5211	135.1406	1571.009	106.1394	10.3021
11/16	36.7174	136.5976	1596.534	107.2838	10.3575
3/4	36.9138	138.0625	1622.234	108.4342	10.4130
13/16	37.1101	139.5351	1648.358	109.5909	10.4683
7/8	37.3065	141.0156	1674.560	110.7536	10.5237
15/16	37.5028	142.5039	1701.140	111.9226	10.5791

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
12 *in.*	37.6992	144	1728	113.0976	10.6345
1/16	37.8955	145.5039	1755.160	114.2788	10.6899
1/8	38.0919	147.0156	1782.564	115.4660	10.7453
3/16	38.2882	148.5351	1810.271	116.6645	10.8007
1/4	38.4846	150.0625	1838.265	117.8590	10.8560
5/16	38.6809	151.5976	1866.539	119.0648	10.9114
3/8	38.8773	153.1406	1895.115	120.2766	10.9668
7/16	39.0736	154.6914	1923.974	121.4946	11.0222
1/2	39.2700	156.25	1953.125	122.7187	11.0776
9/16	39.4663	157.8164	1982.568	123.9490	11.1339
5/8	39.6627	159.3906	2012.306	125.1854	11.1884
11/16	39.8590	160.9726	2042.339	126.4479	11.2437
3/4	40.0554	162.5625	2072.671	127.6765	11.2991
13/16	40.2517	164.1601	2103.301	128.8999	11.3544
7/8	40.4481	165.7656	2134.232	130.1923	11.4099
15/16	40.6444	167.3789	2165.514	131.4279	11.4652
13 *in.*	40.8408	169	2197	132.7326	11.5206
1/16	41.0371	170.6289	2228.840	134.0120	11.5760
1/8	41.2338	172.2656	2260.986	135.2974	11.6314
3/16	41.4298	173.9101	2293.439	136.5890	11.6868
1/4	41.6262	175.5625	2326.203	137.8867	11.7422
5/16	41.8225	177.2226	2359.275	139.1907	11.7976
3/8	42.0189	178.8906	2392.661	140.5007	11.8530
7/16	42.2152	180.5664	2426.361	141.8169	11.9083
1/2	42.4116	182.25	2460.375	143.1391	11.9637
9/16	42.6079	183.9414	2494.705	144.4726	12.0191
5/8	42.8043	185.6406	2529.353	145.8021	12.0745
11/16	43.0006	187.3476	2564.321	147.1428	12.1299
3/4	43.1970	189.0625	2599.609	148.4896	12.1853
13/16	43.3933	190.7851	2634.819	149.8426	12.2407
7/8	43.5897	192.5156	2671.154	151.2017	12.2961
15/16	43.7860	194.2539	2707.413	152.5670	12.3515
14 *in.*	43.9824	196	2744	153.9384	12.4068
1/16	44.1787	197.7539	2780.914	155.3159	12.4622
1/8	44.3751	199.5156	2818.157	156.6995	12.5176
3/16	44.5714	201.2851	2855.732	158.0893	12.5730
1/4	44.7676	203.0625	2893.640	159.4852	12.6284
5/16	44.9641	204.8476	2931.781	160.8374	12.6838
3/8	45.1605	206.6406	2970.458	162.2956	12.7392
7/16	45.3568	208.4414	3009.372	163.7099	12.7946
1/2	45.5532	210.25	3048.625	165.1303	12.8500
9/16	45.7495	212.0664	3088.217	166.5569	12.9053
5/8	45.9459	213.8906	3128.150	167.9896	12.9607
11/16	46.1422	215.7226	3168.425	169.4285	13.0161
3/4	46.3386	217.5625	3209.046	170.8735	13.0715
13/16	46.5349	219.4101	3250.012	172.3247	13.1270
7/8	46.7313	221.2656	3291.325	173.7820	13.1823
15/16	46.9276	223.1289	3332.988	175.2455	13.2377

Dia. or Roet.	Circum.	Square.	Cube.	Area.	Side of = square.
15 *in.*	47.1240	225	3375	176.7150	13.2930
1/16	47.3203	226.8789	3414.781	178.1907	13.3484
1/8	47.5167	228.7656	3460.079	179.6725	13.4038
3/16	47.7130	230.6601	3503.150	181.1105	13.4592
1/4	47.9094	232.5625	3546.578	182.6545	13.5146
5/16	48.1057	234.4726	3590.361	184.1548	13.5700
3/8	48.3021	236.3906	3633.505	185.6612	13.6254
7/16	48.4984	238.3164	3679.009	187.1737	13.6608
1/2	48.6948	240.25	3723.875	188.6923	13.7361
9/16	48.8911	242.1914	3769.103	190.2171	13.7915
5/8	49.0875	244.1406	3814.696	191.7480	13.8470
11/16	49.2838	246.0976	3860.856	193.3351	13.9023
3/4	49.4802	248.0625	3906.984	194.8282	13.9577
13/16	49.6765	250.0351	3953.680	196.3776	14.0131
7/8	49.8729	252.0156	4000.747	197.9330	14.0685
15/16	50.0692	254.0039	4048.187	199.4947	14.1240
16 *in.*	50.2656	256	4096	201.0624	14.1792
1/16	50.4619	258.0039	4144.187	202.6363	14.2346
1/8	50.6583	260.0156	4192.751	204.2162	14.2900
3/16	50.8546	262.0351	4241.693	205.8024	14.3454
1/4	51.0510	264.0625	4291.015	207.3946	14.4008
5/16	51.2473	266.0976	4360.717	208.9931	14.4561
3/8	51.4437	268.1406	4390.802	210.5976	14.5115
7/16	51.6400	270.1914	4441.271	212.2083	14.5670
1/2	51.8364	272.25	4492.125	213.8251	14.6223
9/16	52.0327	274.3164	4544.366	215.4481	14.6777
5/8	52.2291	276.3906	4594.993	217.0772	14.7321
11/16	52.4254	278.4726	4657.011	218.7124	14.7885
3/4	52.6218	280.5625	4699.421	220.3537	14.8439
13/16	52.8181	282.6601	4752.223	222.0013	14.8993
7/8	53.0145	284.7656	4805.419	223.6549	14.9547
15/16	53.2108	286.8789	4859.011	225.3147	15.0101
17 *in.*	53.4072	289	4913	226.9806	15.0654
1/16	53.6035	291.1289	4967.286	228.6527	15.1208
1/8	53.7999	293.2656	5022.173	230.3308	15.1762
3/16	53.9962	295.4101	5077.361	232.0151	15.2316
1/4	54.1926	297.5625	5132.953	233.7055	15.2869
5/16	54.3889	299.7226	5188.947	235.4022	15.3424
3/8	54.5853	301.8906	5245.349	237.1049	15.3977
7/16	54.7816	304.0664	5302.157	238.8138	15.4531
1/2	54.9780	306.25	5359.375	240.5287	15.5085
9/16	55.1743	308.4414	5419.002	242.2499	15.5639
5/8	55.3707	310.6406	5475.040	243.9771	15.6193
11/16	55.5670	312.8476	5533.493	245.7105	15.6747
3/4	55.7634	315.0625	5592.359	247.4500	15.7301
13/16	55.9597	317.2851	5651.640	249.1952	15.7855
7/8	56.1561	319.5156	5711.341	250.9475	15.8408
15/16	56.3524	321.7539	5771.460	252.7050	15.8962

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
18 *in*	56.5488	324	5832	254.4696	15.9516
1/16	56.7451	326.2539	5892.961	256.2398	16.0070
1/8	56.9415	328.5156	5954.345	258.0161	16.0624
3/16	57.1378	330.7851	6016.154	259.7986	16.1178
1/4	57.3342	333.0625	6078.390	261.5872	16.1732
5/16	57.5305	335.3476	6141.053	263.3820	16.2285
3/8	57.7269	337.6406	6204.146	265.1829	16.2839
7/16	57.9232	339.9414	6267.669	266.9900	16.3393
1/2	58.1196	342.25	6331.625	268.8031	16.3947
9/16	58.2159	344.5664	6396.010	270.6225	16.4501
5/8	58.5123	346.8906	6460.837	272.4479	16.5055
11/16	58.7806	349.2226	6566.497	274.2895	16.5609
3/4	58.9056	351.5625	6591.796	276.1171	16.6163
13/16	59.1013	353.9101	6658.933	277.9610	16.6717
7/8	59.2977	356.2656	6724.513	279.8110	16.7270
15/16	59.4940	358.6289	6791.534	281.1672	16.7824
19 *in.*	59.6904	361	6859	283.5294	16.8378
1/16	59.8867	363.3789	6926.910	285.3978	16.8932
1/8	60.0831	365.7656	6995.267	287.2723	16.9486
3/16	60.2794	368.1601	7065.672	289.4030	17.0040
1/4	60.4758	370.5625	7132.328	291.0397	17.0600
5/16	60.6721	372.9726	7203.033	292.9324	17.1147
3/8	60.8685	375.3906	7273.192	294.8312	17.1701
7/16	61.0648	377.8164	7343.785	296.7367	17.2255
1/2	61.2612	380.25	7414.875	298.6483	17.2809
9/16	61.4575	382.6914	7486.410	300.5658	17.3363
5/8	61.6539	385.1406	7558.384	302.4894	17.3917
11/16	61.8502	387.5976	7630.827	304.4192	17.4471
3/4	62.0466	390.0625	7703.734	306.3550	17.5025
13/16	62.2429	392.5351	7777.111	308.2971	17.5579
7/8	62.4393	395.0156	7850.935	310.2452	17.6132
15/16	62.6356	397.5039	7925.234	312.1996	17.6686
20 *in.*	62.8320	400	8000	314.1600	17.7240
1/16	63.0283	402.5039	8075.234	316.1266	17.7794
1/8	63.2247	405.0156	8150.939	318.0992	17.8348
3/16	63.4210	407.5351	8227.114	320.0781	17.8902
1/4	63.6174	410.0625	8303.765	322.0630	17.9456
5/16	63.8137	412.5976	8380.888	324.0542	18.0010
3/8	64.0101	415.1406	8458.489	326.0514	18.0563
7/16	64.2064	417.6914	8536.567	328.0548	18.1117
1/2	64.4028	420.25	8615.125	330.0643	18.1671
9/16	64.5991	422.8164	8694.162	332.0800	18.2225
5/8	64.7955	425.3906	8773.681	334.1018	18.2779
11/16	64.9918	427.9726	8853.683	336.1297	18.3333
3/4	65.1882	430.5625	8934.171	338.1637	18.3887
13/16	65.3845	433.1601	9015.144	340.2040	18.4441
7/8	65.5809	435.7656	9096.607	342.2503	18.4995
15/16	65.7772	438.3789	9178.558	344.3028	18.5549

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
21 *in.*	65.7936	441	9261	346.3614	18.6102
1/16	66.1699	443.6289	9343.933	348.4267	18.6656
1/8	66.3663	446.2656	9427.360	350.4970	18.7210
3/16	66.5626	448.9101	9511.282	352.5740	18.7764
1/4	66.7590	451.5625	9595.703	354.6571	18.8318
5/16	66.9553	454.2226	9680.617	356.7465	18.8872
3/8	67.1517	456.8906	9766.036	358.8419	18.9425
7/16	67.3480	459.5664	9853.954	360.9435	18.9979
1/2	67.5444	462.25	9938.375	363.0511	19.0533
9/16	67.7407	464.9414	10025.29	365.1650	19.1087
5/8	67.9371	467.6406	10112.72	367.2849	19.1641
11/16	68.1334	470.3476	10200.66	369.4110	19.2195
3/4	68.3298	473.0625	10289.11	371.5432	19.2749
13/16	68.5261	475.7851	10378.06	373.6816	19.3303
7/8	68.7225	478.5156	10467.52	375.8261	19.3857
15/16	68.9188	481.2509	10557.54	377.9768	19.4410
22 *in.*	69.1152	484	10648	380.1336	19.4964
1/16	69.3115	486.7539	10739.00	382.2965	19.5518
1/8	69.5079	489.5156	10830.53	384.4655	19.6072
3/16	69.7042	492.2851	10922.57	386.6907	19.6626
1/4	69.9006	495.0625	11015.14	388.8220	19.7180
5/16	70.0969	497.8476	11108.22	391.0095	19.7734
3/8	70.2933	500.6406	11201.83	393.2031	19.8287
7/16	70.4806	503.4414	11295.96	395.4029	19.8841
1/2	70.6860	506.25	11390.62	397.6087	19.9395
9/16	70.8823	509.0664	11485.81	399.8207	19.9949
5/8	71.0787	511.8906	11581.52	402.0388	20.0503
11/16	71.2750	514.7226	11677.76	404.2631	20.1057
3/4	71.4714	517.5625	11774.54	406.4935	20.1611
13/16	71.6677	520.4101	11871.85	408.7301	20.2165
7/8	71.8641	523.2656	11969.70	410.9728	20.2719
15/16	72.0604	526.1289	12068.08	413.2317	20.3272
23 *in.*	72.2568	529	12167	415.4766	20.3826
1/16	72.4531	531.8789	12266.45	417.7377	20.4380
1/8	72.6495	534.7656	12366.45	420.0049	20.4934
3/16	72.8458	537.6601	12466.99	422.2783	20.5490
1/4	73.0422	540.5625	12568.07	424.5577	20.6042
5/16	73.2385	543.4726	12669.70	426.3434	20.6596
3/8	73.4349	546.3906	12771.88	429.1352	20.7150
7/16	73.6312	549.3164	12874.60	431.4331	20.7703
1/2	73.8276	552.25	12977.87	433.7371	20.8257
9/16	74.0239	555.1914	13081.69	436.0473	20.8811
5/8	74.2203	558.1406	13185.98	438.3636	20.9365
11/16	74.4166	561.0976	13290.99	440.6811	20.9919
3/4	74.6130	564.0625	13396.48	443.0146	21.0473
13/16	74.8093	567.0351	13502.52	445.3539	21.1027
7/8	75.0057	570.0156	13609.12	447.6992	21.1581
15/16	75.2020	573.0039	13716.28	450.0418	21.2134

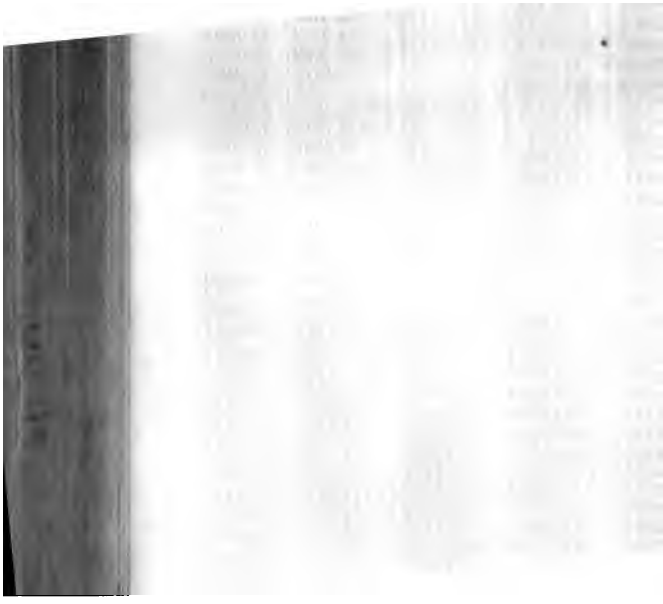
Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
24 in.	75.3984	576	13824	452.3904	21.2608
1/16	75.5947	577.5039	13932.281	454.7497	21.3242
1/8	75.7911	582.0156	14041.128	457.1150	21.3796
3/16	75.9874	583.0351	14150.536	459.4866	21.4350
1/4	76.1838	585.0625	14260.515	461.8642	21.4904
5/16	76.3801	587.0976	14371.070	464.2481	21.5458
3/8	76.5765	589.1406	14482.177	466.6380	21.6012
7/16	76.7728	591.1914	14593.864	469.0341	21.6566
1/2	76.9692	593.25	14706.125	471.4363	21.7119
9/16	77.1655	595.3164	14818.959	473.8447	21.7673
5/8	77.3619	597.3906	14932.368	476.2592	21.8227
11/16	77.5582	599.4726	15046.354	478.6798	21.8781
3/4	77.7546	601.5625	15160.921	481.1065	21.9335
13/16	77.9509	603.6601	15285.065	483.5395	21.9889
7/8	78.1473	605.7656	15391.794	485.9785	22.0443
15/16	78.3436	607.8789	15508.105	488.4237	22.0997
25 in.	78.5400	625	15625	490.8750	22.1550
1/16	78.7363	627.1289	15742.480	493.3325	22.2104
1/8	78.9327	631.2656	15860.548	495.7960	22.2658
3/16	79.1290	634.4101	15979.204	498.2657	22.3212
1/4	79.3254	637.5625	16098.453	500.7415	22.3766
5/16	79.5217	640.7226	16218.290	503.2236	22.4320
3/8	79.7181	643.8906	16338.323	505.7117	22.4873
7/16	79.9144	647.0664	16459.751	508.2060	22.5427
1/2	80.1108	650.25	16581.375	510.7063	22.5981
9/16	80.3071	653.4414	16703.595	513.2129	22.6535
5/8	80.5035	656.6406	16826.415	515.7255	22.7089
11/16	80.6998	659.8476	16949.824	518.2443	22.7643
3/4	80.8962	663.0625	17073.859	520.7692	22.8197
13/16	81.0925	666.2851	17195.482	523.2003	22.8751
7/8	81.2889	669.5156	17323.716	525.6375	22.9305
15/16	81.4852	672.7539	17449.552	528.3809	22.9858
26 in.	81.6816	676	17576	530.9304	23.0412
1/16	81.8779	679.2539	17703.054	533.4860	23.0966
1/8	82.0743	682.5156	17830.720	536.0477	23.1520
3/16	82.2706	685.7851	17924.708	538.6156	23.2074
1/4	82.4670	689.0625	18087.890	541.1896	23.0628
5/16	82.6633	692.3476	18217.396	543.7698	23.3182
3/8	82.8597	695.6406	18347.520	546.3561	23.3735
7/16	83.0560	698.9414	18468.254	548.9486	23.4289
1/2	83.2524	702.25	18609.625	551.5471	23.4843
9/16	83.4487	705.5664	18751.607	554.1519	23.5397
5/8	83.6451	708.8906	18074.212	556.7627	23.5951
11/16	83.8414	712.2226	19007.440	559.3797	23.6505
3/4	84.0378	715.5625	19141.296	562.0027	23.7088
13/16	84.2341	718.9101	19275.767	564.6320	23.7613
7/8	84.4305	722.2656	19410.888	567.2674	23.8166
15/16	84.6268	725.6289	19546.628	569.4090	23.8721

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
27 *in.*	84.8232	729	19683	572.5566	23.9274
1/16	85.0195	732.3789	19820.003	575.2104	23.9828
1/8	85.2159	735.7656	19957.642	577.8703	24.0382
3/16	85.4122	739.1601	20058.957	580.5364	24.0936
1/4	85.6086	742.5625	20234.828	583.2085	24.1490
5/16	85.8049	745.9726	20374.376	585.8869	24.2044
3/8	86.0013	749.3906	20514.567	588.5714	24.2598
7/16	86.1976	752.8164	20655.399	591.2620	24.3192
1/2	86.3940	756.25	20796.875	593.9587	24.3705
9/16	86.5903	759.6914	20942.994	596.6616	24.4269
5/8	86.7867	763.1406	21081.759	599.3706	24.4813
11/16	86.9830	766.5976	21225.171	602.0858	24.5067
3/4	87.1794	770.0625	21369.234	604.8070	24.5921
13/16	87.3757	773.5351	21514.044	607.5345	24.6475
7/8	87.5721	777.0156	21659.309	610.2680	24.7029
15/16	87.7684	780.5039	21805.327	613.0078	24.7583
28 *in.*	87.9648	784	21952	615.7536	24.8136
1/16	88.1611	787.5039	22099.328	618.5051	24.8690
1/8	88.3575	791.0156	22247.313	621.2636	24.9244
3/16	88.5538	794.5351	22395.958	624.0279	24.9797
1/4	88.7502	798.0625	22545.265	626.7982	25.0351
5/16	88.9465	801.5976	22695.231	629.5748	25.0905
3/8	89.1429	805.1406	22845.864	632.3574	25.1459
7/16	89.3392	808.6914	22997.161	635.1462	25.2013
1/2	89.5356	812.25	23149.125	637.9411	25.2567
9/16	89.7319	815.8164	23301.755	640.7422	25.3121
5/8	89.9283	819.3906	23455.056	643.5494	25.3675
11/16	90.1246	822.9726	23609.026	646.3627	25.4229
3/4	90.3210	826.5625	23763.671	649.1821	25.4783
13/16	90.5173	830.1601	23919.007	652.0078	25.5337
7/8	90.7137	833.7656	24074.981	654.8395	25.5891
15/16	90.9100	837.3789	24231.651	657.6774	25.6446
29 *in.*	91.1064	841	24389	660.5214	25.6998
1/16	91.3027	844.6289	24547.027	663.3716	25.7524
1/8	91.4991	848.2656	24705.735	666.2278	25.8106
3/16	91.6954	851.9101	24865.126	669.0902	25.8660
1/4	91.8918	855.5625	25025.203	671.9587	25.9214
5/16	92.0081	859.2226	25195.962	674.8335	26.9768
3/8	92.2845	862.8906	25347.411	677.7143	26.0325
7/16	92.4808	866.5664	25519.548	680.6013	26.0876
1/2	92.6772	870.25	25672.375	683.4943	26.1429
9/16	92.8735	873.9414	25835.892	686.3936	26.1983
5/8	93.0699	877.6406	26000.102	689.2989	26.2537
11/16	93.2662	881.3476	26165.006	692.2104	26.3091
3/4	93.4626	885.0625	26330.609	695.1280	26.3645
13/16	93.6589	888.7851	26496.905	698.0518	26.4799
7/8	*93.8553*	892.5156	26663.903	700.9817	26.4783
15/16	*94.0516*	896.2539	26831.521	703.9178	26.5337

*

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
30 *in.*	94.2480	900	27000	706.8600	26.5860
1/16	94.4443	903.7539	27249.101	709.8083	26.6413
1/8	94.6407	907.5156	27338.907	712.7627	26.6967
3/16	94.8370	911.2851	27463.846	715.7233	26.7521
1/4	95.0334	915.0625	27680.640	718.6900	26.8075
5/16	95.2297	918.8476	27852.567	721.6629	26.8629
3/8	95.4261	922.6406	28025.208	724.6419	26.9183
7/16	95.6224	926.4414	28198.561	727.6271	26.9737
1/2	95.8188	930.25	28372.625	730.6183	27.0291
9/16	96.0151	934.0664	28547.504	733.6158	27.0844
5/8	96.2115	937.8906	28722.899	736.6193	27.1398
11/16	96.4078	941.7226	28899.122	739.6290	27.1952
3/4	96.6042	945.5625	29076.046	742.6447	27.2506
13/16	96.8005	949.4101	29253.698	745.6667	27.3060
7/8	96.9969	953.2656	29432.075	748.6948	27.3614
15/16	97.1932	957.1289	29606.975	751.7291	27.4168
31 *in.*	97.3896	961	29791	754.7694	27.4722
1/16	97.5859	964.8789	29979.550	757.8159	27.5275
1/8	97.7823	968.7656	30152.829	760.8685	27.5829
3/16	97.9786	972.6601	30296.203	763.9273	27.6383
1/4	98.1750	976.5625	30517.578	766.9921	27.6937
5/16	98.3713	980.4726	30701.048	770.0632	27.7491
3/8	98.5677	984.3906	30885.255	773.1404	27.8045
7/16	98.7648	988.3164	30946.712	776.2237	27.8599
1/2	98.9684	992.25	31255.875	779.3131	27.9153
9/16	99.1567	996.1914	31442.191	782.4087	27.9706
5/8	99.3531	1000.140	31629.446	785.5104	28.0260
11/16	99.5494	1004.097	31817.542	788.6183	28.0814
3/4	99.7458	1008.062	32005.984	791.7322	28.1368
13/16	99.9421	1012.035	32195.366	794.8524	28.1922
7/8	100.1385	1016.015	32385.497	797.9786	28.2476
15/16	100.3348	1020.003	32576.375	801.1111	28.3030
in.	100.5312	1024	32768	804.2496	28.3584
1/16	100.7275	1028.003	32960.375	807.3943	28.4137
1/8	100.9240	1032.015	33153.501	810.5450	28.4691
3/16	101.1202	1036.035	33295.578	813.7020	28.5245
1/4	101.3166	1040.062	33542.015	816.8650	28.5799
5/16	101.5130	1044.097	33737.403	820.0343	28.6352
3/8	101.7093	1048.840	33956.314	823.2096	28.6912
7/16	101.9056	1052.191	34130.258	826.3911	28.7466
1/2	102.1020	1056.25	34328.125	829.6787	28.8015
9/16	102.2983	1060.316	34526.552	832.7725	28.8568
5/8	102.4947	1064.390	34725.743	835.9724	28.9122
11/16	102.6910	1068.472	34925.698	839.1784	28.9676
3/4	102.8874	1072.562	35026.421	842.3905	29.0230
13/16	103.0837	1076.660	35327.909	845.6089	29.0784
7/8	103.2801	1080.765	35530.169	848.8333	29.1338
15/16	103.4764	1084.878	35733.198	852.0639	29.1892

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
33 *in.*	103.6728	1089	35937	855.3006	29.2446
1/16	103.8691	1093.129	36141.577	858.5436	29.2999
1/8	104.0655	1097.265	36354.928	861.7924	29.3553
3/16	104.2618	1101.410	36553.144	865.0475	29.4107
1/4	104.4582	1105.562	36759.944	868.3087	29.4661
5/16	104.6545	1109.722	36967.614	871.5760	29.5215
3/8	104.8509	1113.890	37256.088	874.8497	29.5769
7/16	105.0472	1118.066	37385.332	878.1290	29.6323
1/2	105.2436	1122.25	37595.375	881.4151	29.6877
9/16	105.4399	1126.441	37806.176	884.7070	29.7431
5/8	105.6363	1130.640	38017.784	888.0051	29.7985
11/16	105.8326	1134.847	38230.158	891.3090	29.8539
3/4	106.0290	1139.062	38443.352	894.6196	29.9092
13/16	106.2253	1143.285	38657.324	897.9360	29.9646
7/8	106.4217	1147.515	38872.088	901.2587	30.0200
15/16	106.6180	1151.754	39087.651	904.5875	30.0754
34 *in.*	106.8144	1156	39304	907.9224	30.1308
1/16	107.0107	1160.254	39521.152	911.2645	30.1862
1/8	107.2071	1164.515	39738.288	914.6105	30.2416
3/16	107.4034	1168.785	39957.837	917.9640	30.2970
1/4	107.5998	1173.062	40177.384	921.3232	30.3523
5/16	107.7961	1177.347	40397.719	924.6883	30.4077
3/8	107.9925	1181.640	40618.888	928.0605	30.4631
7/16	108.1888	1185.941	40840.843	931.4380	30.5185
1/2	108.3852	1190.25	41063.625	934.8223	30.5739
9/16	108.5815	1194.566	41287.187	938.2121	30.6293
5/8	108.7779	1198.890	41511.576	941.6087	30.6847
11/16	108.9742	1203.222	41736.763	945.0110	30.7400
3/4	109.1706	1207.562	41962.792	948.4195	30.7954
13/16	109.3669	1211.910	42189.617	951.8341	30.8508
7/8	109.5633	1216.265	42417.256	955.2550	30.9062
15/16	109.7596	1220.629	42695.725	958.6820	30.9616
35 *in.*	109.9560	1225	42875	962.1150	31.0170
1/16	110.1523	1229.379	43105.081	965.5542	31.0724
1/8	110.3487	1233.765	43352.016	968.9995	31.1278
3/16	110.5450	1238.160	43567.755	972.4510	31.1831
1/4	110.7414	1242.562	43800.320	975.9085	31.2386
5/16	110.9377	1246.968	44033.557	979.3686	31.2939
3/8	111.1341	1251.390	44267.944	982.8422	31.3493
7/16	111.3304	1255.816	44502.979	986.3180	31.4047
1/2	111.5268	1260.25	44738.875	989.8003	31.4601
9/16	111.7231	1264.591	44972.017	993.2097	31.5155
5/8	111.9195	1269.140	45213.120	996.7830	31.5709
11/16	112.1158	1273.597	45451.493	1000.3472	31.6263
3/4	112.3122	1278.062	45690.728	1003.7962	31.6817
13/16	112.5086	1282.535	45930.784	1007.3030	31.7370
7/8	112.7049	1287.015	46171.680	1010.8220	31.7924
15/16	112.9012	1291.504	46413.425	1014.3472	31.8478



Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
36 *in.*	113.0976	1296	46656	1017.8784	31.9032
1/16	113.2939	1306.503	47115.796	1021.4158	31.9585
1/8	113.4903	1308.015	47252.063	1024.9592	32.0139
3/16	113.6866	1309.535	47388.801	1028.5089	32.0693
1/4	113.8830	1314.062	47634.765	1032.0646	32.1247
5/16	114.0793	1318.597	47881.565	1035.6266	32.1801
3/8	114.2757	1323.140	48129.239	1039.1946	32.2355
7/16	114.4720	1327.691	48377.795	1042.7913	32.2909
1/2	114.6684	1332.25	48627.125	1046.3941	32.3463
9/16	114.8647	1336.816	48877.349	1049.9581	32.4016
5/8	115.0611	1341.390	49128.430	1053.5281	32.4570
11/16	115.2572	1345.972	49380.360	1057.1269	32.5124
3/4	115.4538	1350.562	49633.171	1060.7317	32.5678
13/16	115.6501	1355.160	49886.831	1064.3428	32.6232
7/8	115.8465	1359.765	50141.356	1067.9599	32.6786
15/16	116.0428	1364 378	50396.745	1071.5832	32.7340
37 *in.*	116.2392	1369	50653	1075.2126	32.7894
1/16	116.4355	1373.628	51010.121	1078.8482	32.8447
1/8	116.6319	1378.265	51168.110	1082.4898	32.9001
3/16	116.8282	1382.910	51426.969	1086.1376	32.9555
1/4	117.0246	1387.562	51686.703	1089.7915	33.0109
5/16	117.2209	1392.222	52447.305	1093.4517	33.0663
3/8	117.4173	1396.890	52208.786	1097.1179	33.0217
7/16	117.6136	1401.566	52471.142	1100.7903	33.1771
1/2	117.8100	1406.25	52734.375	1104.4687	33.2325
9/16	118.0063	1410.941	52998.497	1108.1534	33.2878
5/8	118.2027	1415.640	53263.477	1111.8441	33.3432
11/16	118.3990	1420.347	53517.892	1115.5410	33.3986
3/4	118.5954	1425.062	53796.109	1119.2440	33.4540
13/16	118.7917	1429.785	54063.629	1122.9532	33.5094
7/8	118.9881	1434.515	54332.278	1126.6685	33.5648
15/16	119.1844	1439.253	54601.694	1130.3900	33.6202
38 *in.*	119.3808	1444	54872	1134.1176	33.6756
1/16	119.5771	1448.753	55143.195	1137.8513	33.7309
1/8	119.7735	1453.515	55415.282	1141.5911	33.7863
3/16	119.9698	1458.285	55687.252	1145.3371	33.8417
1/4	120.1662	1463.062	55962.140	1149.0892	33.8971
5/16	120.3625	1467.847	56236.915	1152.8475	33.9525
3/8	120.5589	1472.640	56512.583	1156.6119	34.0079
7/16	120.7552	1477.441	56789.213	1160.3825	34.0633
1/2	120.9516	1482.25	57066.625	1164.1591	34.1187
9/16	121.1479	1487.066	57244.998	1167.9420	34.1740
5/8	121.3443	1491.890	57624.274	1171.7309	34.2294
11/16	121.5406	1496.722	57904.455	1175.5260	34.2848
3/4	121.7370	1501.562	58185.546	1179.3271	34.3402
13/16	121.9333	1506.410	58467.542	1183.1345	34.3956
7/8	122.1297	1511.265	58750.450	1186.9480	34.4510
15/16	122.3260	1516.128	59034.251	1190.7677	34.5064

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
39 *in.*	122.5224	1521	59319	1194.5934	34.5618
1/16	122.7187	1525.878	59604.445	1198.4253	34.6171
1/8	122.9151	1530.765	59891.204	1202.2633	34.6725
3/16	123.1114	1535.660	60178.680	1206.1075	34.7279
1/4	123.3078	1540.562	60466.078	1209.9577	34.7833
5/16	123.5041	1545.472	60756.391	1213.8142	34.8387
3/8	123.7005	1550.390	61046.629	1217.6768	34.8941
7/16	123.8968	1555.316	61337.798	1221.5455	34.9495
1/2	124.0932	1560.25	61629.875	1225.4203	35.0049
9/16	124.2895	1565.191	61922.884	1229.3013	35.0602
5/8	124.4859	1570.140	62216.822	1233.1884	35.1156
11/16	124.6822	1575.097	62511.636	1237.0817	35.1710
3/4	124.8786	1580.062	62807.484	1240.9810	35.2264
13/16	125.0749	1585.035	63304.209	1244.8866	35.2818
7/8	125.2713	1590.015	63401.872	1248.7982	35.3372
15/16	125.4676	1595.003	63700.468	1252.7161	35.3926
40 *in.*	125.6640	1600	64000	1256.6400	35.4480
1/16	125.8603	1605.003	64300.468	1260.5701	35.5033
1/8	126.0567	1610.015	64601.375	1264.5062	35.5587
3/16	126.2530	1615.035	64894.223	1268.4486	35.6141
1/4	126.4494	1620.062	65207.515	1272.3970	35.6695
5/16	126.6457	1625.097	65511.747	1276.3517	35.7249
3/8	126.8421	1630.140	65816.926	1280.3124	35.7803
7/16	127.0384	1635.191	66123.052	1284.2793	35.8357
1/2	127.2348	1640.25	66430.125	1288.2523	35.8911
9/16	127.4311	1645.316	66738.146	1292.2315	35.9464
5/8	127.6275	1650.390	67047.110	1296.2168	36.0018
11/16	127.8238	1655.472	67357.041	1300.2082	36.0572
3/4	128.0202	1660.562	67667.925	1304.2057	36.1126
13/16	128.2165	1665.660	67971.590	1308.2095	36.1680
7/8	128.4129	1670.765	68292.539	1312.2193	36.2234
15/16	128.6092	1675.878	68706.292	1316.2353	36.2788
41 *in.*	128.8056	1681	68921	1320.2574	36.3342
1/16	129.0019	1686.128	69236.667	1324.2857	36.3895
1/8	129.1983	1691.265	69553.297	1328.3200	36.4449
3/16	129.3946	1696.410	69870.890	1332.3605	36.5003
1/4	129.5910	1701.562	70189.453	1336.4071	36.5557
5/16	129.7873	1706.722	70508.977	1340.4600	36.6111
3/8	129.9837	1711.890	70829.473	1344.5189	36.6665
7/16	130.1800	1717.066	71150.938	1348.5840	36.7219
1/2	130.3764	1722.25	71473.375	1352.6551	36.7773
9/16	130.5727	1727.441	71703.482	1356.7325	36.8326
5/8	130.7691	1732.640	72121.164	1360.8159	36.8880
11/16	130.9654	1737.847	72444.541	1364.9055	36.9434
3/4	131.1618	1743.062	72772.859	1369.0012	36.9988
13/16	131.3581	1748.285	73100.170	1373.1031	37.0542
7/8	131.5545	1753.515	73428.465	1377.2111	37.1096
15/16	131.7508	1758.753	73757.791	1381.3253	37.1650

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
42 *in.*	131.9472	1764	74088	1385.4456	37.2204
1/16	132.1435	1769.253	74419.242	1389.5720	37.2757
1/8	132.3399	1774.515	74751.469	1393.7045	37.3311
3/16	132.5362	1779.785	75084.683	1397.8432	37.3865
1/4	132.7326	1785.062	75418.890	1401.9880	37.4419
5/16	132.9289	1790.347	75711.770	1406.1390	37.4973
3/8	133.1253	1795.640	76090.270	1410.2961	37.5527
7/16	133.3216	1800.941	76426.450	1414.4594	37.6081
1/2	133.5180	1806.25	76765.625	1418.6287	37.6635
9/16	133.7143	1811.566	77304.794	1422.8043	37.7188
5/8	133.9107	1816.890	77444.961	1426.9859	37.7742
11/16	134.1070	1822.222	77786.127	1431.1737	37.8296
3/4	134.3034	1827.562	78128.296	1435.3675	37.8850
13/16	134.4997	1832.910	78471.463	1439.5676	37.9404
7/8	134.6961	1838.265	78815.637	1443.7738	37.9958
15/16	134.8924	1843.628	79160.815	1447.9862	38.0512
43 *in.*	135.0888	1849	79507	1452.2046	38.1066
1/16	135.2851	1854.378	79854.191	1456.4292	38.1619
1/8	135.4815	1859.765	80202.391	1460.6599	38.2173
3/16	135.6778	1865.160	80551.601	1464.8968	38.2727
1/4	135.8742	1870.562	80901.828	1469.1397	38.3281
5/16	136.0705	1875.972	81253.063	1473.3889	38.3835
3/8	136.2669	1881.390	81605.317	1477.6342	38.4389
7/16	136.4632	1886.816	81958.587	1481.9006	38.4943
1/2	136.6596	1892.25	82312.875	1486.1731	38.5497
9/16	136.8559	1897.691	82668.181	1490.4468	38.6050
5/8	137.0523	1903.140	83024.508	1494.7266	38.6604
11/16	137.2486	1908.597	83382.857	1499.0126	38.7158
3/4	137.4450	1914.062	83740.234	1503.3046	38.7712
13/16	137.6413	1919.535	84099.631	1507.6029	38.8266
7/8	137.8377	1925.015	84460.059	1511.9072	38.8820
15/16	138.0340	1930.503	84831.515	1516.2178	38.9374
44 *in.*	138.2304	1936	85184	1520.5344	38.9928
1/16	138.4267	1941.503	85547.515	1524.8572	39.0481
1/8	138.6231	1947.015	85912.063	1529.1860	39.1035
3/16	138.8194	1952.535	86278.844	1533.5211	39.1589
1/4	139.0158	1958.062	86644.265	1537.8622	39.2143
5/16	139.2121	1963.597	87011.918	1542.2046	39.2697
3/8	139.4085	1969.140	87380.614	1546.5530	39.3251
7/16	139.6048	1974.691	87740.259	1550.9176	39.3805
1/2	139.8012	1980.25	88121.125	1555.2883	39.4359
9/16	139.9975	1985.816	88492.943	1559.6602	39.4912
5/8	140.1939	1991.390	88865.805	1564.0382	39.5466
11/16	140.3902	1996.972	89239.713	1568.4223	39.6020
3/4	140.5866	2002.562	89614.652	1572.8125	39.6574
13/16	140.7829	2008.160	89990.674	1577.2090	39.7128
7/8	140.9793	2013.765	90367.731	1581.6115	39.7682
15/16	141.1756	2019.378	90745.839	1586.0203	39.8236

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
45 *in.*	141.3720	2025	91125	1590.4350	39.8799
1/16	141.5683	2030.628	91515.214	1594.4560	39.9343
1/8	141.7647	2036.265	91886.485	1599.2830	39.9897
3/16	141.9610	2041.910	92268.812	1603.7162	40.0451
1/4	142.1574	2047.562	92652.203	1608.1555	40.1005
5/16	142.3537	2053.222	93036.640	1612.5961	40.1559
3/8	142.5501	2058.890	93422.161	1617.0427	40.2113
7/16	142.7464	2064.566	93808.735	1621.5055	40.2667
1/2	142.9428	2070.25	94196.375	1625.9743	40.3221
9/16	143.1391	2075.941	94585.080	1630.4444	40.3774
5/8	143.3355	2081.640	94974.852	1634.9205	40.4328
11/16	143.5318	2087.347	95363.694	1639.4028	40.4882
3/4	143.7282	2093.062	95757.609	1643.8912	40.5436
13/16	143.9245	2098.785	96149.592	1648.3858	40.5990
7/8	144.1209	2104.515	96544.653	1652.8865	40.6544
15/16	144.3172	2110.253	97239.788	1657.3934	40.7098
46 *in.*	144.5136	2116	97336	1661.9064	40.7652
1/16	144.7099	2121.753	97733.289	1666.4255	40.8025
1/8	144.9063	2127.515	98131.657	1670.9507	40.8759
3/16	145.1026	2133.285	98231.103	1675.4821	40.9313
1/4	145.2990	2139.062	98931.640	1680.0196	40.9867
5/16	145.4953	2144.847	99333.254	1684.5583	41.0421
3/8	145.6917	2150.640	99735.957	1689.1031	41.0975
7/16	145.8880	2156.441	100139.447	1693.6641	41.1529
1/2	146.0844	2162.25	100544.625	1698.2311	41.2083
9/16	146.2807	2168.066	100950.601	1702.7994	41.2636
5/8	146.4771	2173.890	101357.649	1707.3737	41.3190
11/16	146.6734	2179.722	101765.778	1711.9542	41.3744
3/4	146.8698	2185.562	102175.046	1716.5407	41.4298
13/16	147.0661	2191.410	102185.385	1721.1335	41.4852
7/8	147.2625	2197.265	102996.825	1725.7324	41.5406
15/16	147.4588	2203.128	103413.900	1730.3375	41.5960
47 *in.*	147.6552	2209	103823	1734.9486	41.6514
1/16	147.8515	2214.878	104237.738	1739.5659	41.7067
1/8	148.0479	2220.765	104653.579	1744.1893	41.7621
3/16	148.2442	2226.660	105070.523	1748.8189	41.8175
1/4	148.4406	2232.562	105488.578	1753.4545	41.8729
5/16	148.6369	2238.472	105907.734	1758.0914	41.9283
3/8	148.8333	2244.390	106328.004	1762.7344	41.9837
7/16	149.0296	2250.316	106749.384	1767.3935	42.0391
1/2	149.2260	2256.25	107171.875	1772.0587	42.0945
9/16	149.4223	2262.191	107593.478	1776.7251	42.1498
5/8	149.6187	2268.140	108020.196	1781.3976	42.2052
11/16	149.8150	2274.097	108446.029	1786.0763	42.2606
3/4	150.0114	2280.062	108872.984	1790.7610	42.3160
13/16	150.2077	2286.035	109310.753	1795.4520	42.3714
7/8	150.4041	2292.015	109730.246	1800.1490	42.4268
15/16	150.6004	2298.003	110160.561	1804.8523	42.4822

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
48 *in.*	150.7968	2304	110592	1809.5616	42.5376
1/16	150.9931	2310.004	111024.610	1814.2351	42.5923
1/8	151.1895	2316.015	111458.250	1818.9088	42.6469
3/16	151.3858	2322.035	111993.066	1823.7264	42.7037
1/4	151.5822	2328.062	112329.015	1828.4602	42.7591
5/16	151.7785	2334.097	112855.090	1833.1953	42.8145
3/8	151.9749	2340.140	113204.301	1837.9304	42.8699
7/16	152.1712	2346.191	113543.645	1842.6937	42.9253
1/2	152.3676	2352.25	114084.125	1847.4571	42.9807
9/16	152.5639	2358.316	114725.740	1852.2167	43.0361
5/8	152.7603	2364.390	114968.493	1856.9924	43.0915
11/16	152.9566	2370.472	115412.384	1861.7892	43.1468
3/4	153.1530	2376.562	115857.421	1868.5521	43.2022
13/16	153.3493	2382.660	116303.596	1871.3413	43.2576
7/8	153.5457	2388.765	116750.918	1876.1365	43.3130
15/16	153.7420	2394.878	117199.386	1880.9379	43.3684
49 *in.*	153.9384	2401	117649	1885.7454	43.4238
1/16	154.1347	2407.129	118099.810	1890.5591	43.4791
1/8	154.3311	2413.265	118551.672	1895.3788	43.5345
3/16	154.5274	2419.410	119004.734	1900.2047	43.5899
1/4	154.7238	2425.562	119458.953	1905.0367	43.6453
5/16	154.9201	2431.722	119914.320	1909.8700	43.7007
3/8	155.1165	2437.890	120370.848	1914.7093	43.7561
7/16	155.3128	2444.066	120828.532	1919.5648	43.8115
1/2	155.5092	2450.25	121287.375	1924.4263	43.8669
9/16	155.7055	2456.441	121747.376	1929.2891	43.9223
5/8	155.9019	2462.640	122208.539	1934.1579	43.9777
11/16	156.0982	2468.847	122671.264	1939.0329	44.0330
3/4	156.2946	2475.062	123134.359	1943.9140	44.0884
13/16	156.4909	2481.285	123599.014	1948.8013	44.1438
7/8	156.6873	2487.515	124064.336	1953.6947	44.1992
15/16	156.8836	2493.753	124531.835	1958.0943	44.2546
50 *in.*	157.0800	2500	125000	1963.5000	44.3100
1/16	157.2763	2506.254	125469.386	1968.4118	44.3653
1/8	157.4727	2512.515	125939.844	1973.3297	44.4207
3/16	157.6690	2518.785	126411.527	1978.2525	44.4761
1/4	157.8654	2525.062	126884.390	1983.1840	44.5315
5/16	158.0617	2531.347	127358.426	1988.6154	44.5869
3/8	158.2581	2537.640	127833.645	1993.0529	44.6423
7/16	158.4544	2543.941	128310.004	1998.0066	44.6977
1/2	158.6508	2550.25	128787.625	2002.9663	44.7531
9/16	158.8471	2556.566	129266.388	2007.9273	44.8085
5/8	159.0435	2562.890	129746.336	2012.8943	44.8639
11/16	159.2398	2569.222	130327.469	2017.8675	44.9192
3/4	159.4362	2575.562	130709.797	2022.8467	44.9746
13/16	159.6325	2581.910	131193.306	2027.8172	45.0300
7/8	159.8289	2588.265	131678.012	2032.8238	45.0854
15/16	160.0252	2594.628	132163.909	2037.8216	45.1408

No. of Rods.	Circum.	Square.	Cube.	Area.	Side of square.
52 in.	163.3762	2704	140608	2123.7216	46.0824
1/16	163.5543	2710.594	141115.681	2128.8298	46.1377
1/8	163.7559	2717.015	141524.433	2133.9440	46.1931
3/16	163.9522	2723.535	142134.359	2139.0645	46.2485
1/4	164.1496	2730.062	142845.765	2144.1910	46.3039
5/16	164.3449	2736.597	143153.251	2149.3238	46.3593
3/8	164.5413	2743.140	143971.939	2154.4626	46.4147
7/16	164.7376	2749.691	144186.942	2159.6076	46.4701
1/2	164.9349	2756.25	144703.125	2164.7587	46.5255
9/16	165.1303	2762.816	145219.537	2169.9160	46.5809
5/8	165.3267	2769.390	145739.180	2175.0794	46.6363
11/16	165.5230	2775.972	146606.052	2180.2489	46.6916
3/4	165.7194	2782.562	146780.172	2185.4245	46.7470
13/16	165.9157	2789.160	146953.872	2190.6064	46.8024
7/8	166.1121	2795.765	147826.106	2195.7943	46.8578
15/16	166.3084	2802.378	148350.893	2200.9884	46.9132
53 in.	166.5048	2809	148877	2206.1886	46.9686
1/16	166.7011	2815.629	149404.361	2211.3950	47.0239
1/8	166.8975	2822.265	149932.860	2216.6074	47.0793
3/16	167.0938	2828.910	150462.655	2221.8260	47.1347
1/4	167.2902	2835.562	150993.703	2227.0507	47.1901
5/16	167.4865	2842.222	151525.992	2232.2817	47.2455
3/8	167.6829	2848.890	152059.535	2237.5187	47.3009
7/16	167.8792	2855.566	152594.329	2242.7619	47.3563
1/2	168.0756	2862.25	153130.375	2248.0111	47.4117
9/16	168.2719	2868.941	153667.673	2253.2666	47.4671
5/8	168.4683	2875.640	154206.227	2258.5281	47.5225
11/16	168.6646	2882.347	154746.036	2263.7908	47.5778
3/4	168.8610	2889.062	155287.109	2269.0696	47.6332
13/16	169.0573	2895.785	155829.336	2274.3496	47.6886
7/8	169.2537	2902.515	156373.028	2279.6357	47.7440
15/16	169.4500	2909.253	156917.852	2284.9280	47.7994

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of square.
54 *in.*	169.6464	2916	157464	2290.2264	47.8548
1/16	169.8427	2922.754	158011.436	2295.5309	47.9101
1/8	170.0391	2929.515	158560.032	2300.8415	47.9655
3/16	170.2354	2936.285	159109.948	2306.1583	48.0209
1/4	170.4318	2943.062	159661.140	2311.4812	48.0763
5/16	170.6281	2949.847	160213.597	2316.8103	48.1317
3/8	170.8245	2956.640	160767.332	2322.1455	48.1871
7/16	171.0208	2963.441	161322.541	2327.4819	48.2425
1/2	171.2172	2970.25	161878.625	2332.8343	48.2979
9/16	171.4135	2977.066	162436.185	2338.1899	48.3533
5/8	171.6099	2983.890	162995.024	2343.5477	48.4087
11/16	171.8062	2990.722	163854.242	2348.9636	48.4640
3/4	172.0026	2997.562	164116.547	2354.2855	48.5194
13/16	172.1989	3004.410	164679.328	2359.6637	48.5748
7/8	172.3953	3011.265	165243.199	2365.0480	48.6302
15/16	172.5916	3018.128	165808.456	2370.4385	48.6856
55 *in.*	172.7880	3025	166375	2375.8350	48.7410
1/16	172.9843	3031.879	166942.886	2381.2382	48.7963
1/8	173.1807	3038.765	167511.953	2386.6465	48.8517
3/16	173.3770	3045.660	168295.866	2392.0515	48.9071
1/4	173.5734	3052.562	168654.078	2397.4625	48.9625
5/16	173.7697	3059.472	169225.578	2402.9098	49.0179
3/8	173.9661	3066.390	169801.379	2408.3432	49.0733
7/16	174.1624	3073.316	170169.779	2413.7777	49.1287
1/2	174.3588	3080.25	170953.875	2419.2283	49.1841
9/16	174.5551	3087.191	171532.072	2424.7026	49.2395
5/8	174.7515	3094.140	172111.570	2430.1830	49.2949
11/16	174.9478	3101.097	172692.372	2435.6246	49.3502
3/4	175.1442	3108.062	173274.484	2441.0722	49.4056
13/16	175.3405	3115.035	173856.496	2446.5486	49.4610
7/8	175.5369	3122.015	174442.621	2452.0310	49.5164
15/16	175.7332	3129.003	175028.655	2457.0197	49.5718
56 *in.*	175.9296	3136.	175616	2463.0144	49.6272
1/16	176.1259	3143.004	176204.712	2468.5153	49.6825
1/8	176.3223	3150.015	176794.625	2474.0222	49.7379
3/16	176.5186	3157.035	177385.909	2479.5354	49.7933
1/4	176.7150	3164.062	177978.515	2485.0546	49.8487
5/16	176.9113	3171.097	178572.433	2490.5351	49.9041
3/8	177.1077	3178.140	179167.676	2496.1116	49.9595
7/16	177.3040	3185.191	179764.239	2501.6493	50.0149
1/2	177.5004	3192.25	180362.125	2507.1931	50.0703
9/16	177.6967	3199.316	180961.343	2512.7431	50.1257
5/8	177.8931	3206.390	181561.867	2518.2992	50.1811
11/16	178.0894	3213.472	182163.728	2523.8614	50.2364
3/4	178.2858	3220.562	182766.921	2529.4297	50.2918
13/16	178.4821	3227.660	183371.441	2535.0043	50.3472
7/8	178.6785	3234.765	183977.293	2540.5849	50.4026
15/16	178.8748	3241.878	184384.489	2546.1717	50.4580

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
57 in.	179.0712	3249	185193	2551.7646	50.5134
1/16	179.2675	3256.129	185802.912	2557.3837	50.5687
1/8	179.4639	3263.265	186414.047	2562.9988	50.6241
3/16	179.6602	3270.410	187026.577	2568.5891	50.6795
1/4	179.8566	3277.562	187640.453	2574.1975	50.7349
5/16	180.0529	3284.722	188255.664	2579.8212	50.7903
3/8	180.2493	3291.890	188872.223	2585.4509	50.8457
7/16	180.4456	3299.066	189490.126	2591.0869	50.9011
1/2	180.6420	3306.25	190109.375	2596.7287	50.9565
9/16	180.8383	3313.441	190729.970	2602.3769	51.0119
5/8	181.0347	3320.640	191351.914	2608.0311	51.0673
11/16	181.2310	3327.847	191985.008	2613.6942	51.1226
3/4	181.4274	3335.062	192599.859	2619.3580	51.1780
13/16	181.6237	3342.285	193225.857	2625.0307	51.2334
7/8	181.8201	3349.515	193853.215	2630.7095	51.2888
15/16	182.0164	3356.753	194471.829	2636.3945	51.3442
58 in.	182.2128	3364	195112	2642.0856	51.3996
1/16	182.4091	3371.254	195743.487	2647.7328	51.4549
1/8	182.6055	3378.515	196376.219	2653.4861	51.5103
3/16	182.8018	3385.785	197010.370	2659.2565	51.5657
1/4	182.9982	3393.062	197645.890	2664.9112	51.6211
5/16	183.1945	3400.347	198282.869	2670.6330	51.6765
3/8	183.3909	3407.640	198921.020	2676.3609	51.7319
7/16	183.5872	3414.941	199561.638	2682.0950	51.7873
1/2	183.7836	3422.25	200201.625	2687.8351	51.8427
9/16	183.9799	3429.566	200743.982	2693.5814	51.8981
5/8	184.1763	3436.890	201487.711	2699.3338	51.9535
11/16	184.3726	3444.222	202132.813	2705.0924	52.0088
3/4	184.5690	3451.562	202779.296	2710.8571	52.0642
13/16	184.7653	3458.910	203027.158	2716.6280	52.1196
7/8	184.9617	3466.265	204076.387	2722.4050	52.1750
15/16	185.1580	3473.628	204729.005	2728.1882	52.2304
59 in.	185.3544	3481	205379	2733.9774	52.2858
1/16	185.5507	3488.379	206032.437	2739.7728	52.3411
1/8	185.7471	3495.765	206687.141	2745.5743	52.3965
3/16	185.9434	3503.160	207343.288	2751.3820	52.4519
1/4	186.1398	3510.562	208000.828	2757.1957	52.5073
5/16	186.3361	3517.972	208659.649	2763.0157	52.5627
3/8	186.5325	3525.390	209320.066	2768.8418	52.6181
7/16	186.7288	3532.816	209981.374	2774.6745	52.6735
1/2	186.9252	3540.25	210644.875	2780.5123	52.7289
9/16	187.1215	3547.691	211309.369	2786.3568	52.7843
5/8	187.3179	3555.140	212975.258	2792.2074	52.8397
11/16	187.5142	3562.597	212642.544	2798.0642	52.8950
3/4	187.7106	3570.062	213311.234	2803.9270	52.9504
13/16	187.9069	3577.535	213981.318	2809.7461	53.0058
7/8	188.1033	3585.015	214642.809	2815.8712	53.0612
15/16	188.2996	3592.503	215325.702	2821.5526	53.1166

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
60 *in.*	188.4960	3600	216000	2827.4400	53.1720
1/16	188.6923	3607.503	216676.003	2833.3336	53.2274
1/8	188.8887	3615.015	217352.813	2839.2332	53.2828
3/16	189.0850	3622.535	218041.381	2845.1391	53.3381
1/4	189.2814	3630.062	218711.265	2851.0510	53.3935
5/16	189.4777	3637.597	219392.605	2856.9692	53.4489
3/8	189.6741	3645.140	220075.363	2862.8934	53.5043
7/16	189.8704	3652.691	221759.536	2868.8223	53.5597
1/2	189.0668	3660.25	221445.125	2874.7603	53.6151
9/16	190.2631	3667.816	222132.140	2880.7030	53.6705
5/8	190.4595	3675.390	222820.555	2886.6517	53.7259
11/16	190.6558	3682.972	223510.400	2892.6067	53.7813
3/4	190.8522	3690.562	224201.672	2898.5677	53.8367
13/16	191.0485	3698.160	224894.361	2904.5350	53.8920
7/8	191.2449	3705.765	225588.481	2910.5083	53.9474
15/16	191.4412	3713.378	226284.016	2916.4878	54.0028
61 *in.*	191.6376	3721	226981	2922.4734	54.0582
1/16	191.8339	3728.628	227679.402	2928.4652	54.1136
1/8	192.0303	3736.265	228379.235	2934.4630	54.1680
3/16	192.2266	3743.910	229079.699	2940.4670	54.2243
1/4	192.4230	3751.562	229783.203	2946.4771	54.2797
5/16	192.6193	3759.222	230487.336	2952.4938	54.3351
3/8	192.8157	3766.890	231192.911	2958.5159	54.3905
7/16	193.0120	3774.566	231949.923	2964.5445	54.4459
1/2	193.2084	3782.25	232608.375	2970.5791	54.5013
9/16	193.4047	3789.941	233311.067	2976.6200	54.5567
5/8	193.6011	3797.640	234029.602	2982.6669	54.6121
11/16	193.7974	3805.347	234744.380	2988.7200	54.6675
3/4	193.9938	3813.062	235456.609	2994.7792	54.7229
13/16	194.1901	3820.785	236172.279	3000.8423	54.7782
7/8	194.3865	3828.515	236889.403	3006.9161	54.8336
15/16	194.5828	3836.253	237607.976	3017.9938	54.8890
62 *in.*	194.7792	3844	238328	3019.0776	54.9444
1/16	194.9755	3851.753	239050.476	3025.1675	54.9998
1/8	195.1719	3859.515	239772.406	3031.2635	55.0552
3/16	195.3682	3867.285	240496.792	3037.3607	55.1105
1/4	195.5646	3875.062	241222.640	3043.4740	55.1659
5/16	195.7609	3882.847	241948.941	3049.6885	55.2213
3/8	195.9573	3890.640	242678.707	3055.7091	55.2767
7/16	196.1536	3898.441	243408.935	3061.8359	55.3321
1/2	196.3500	3906.25	244140.625	3067.9687	55.3875
9/16	196.5463	3914.066	244873.779	3074.1578	55.4429
5/8	196.7427	3921.890	245608.399	3080.2529	55.4983
11/16	196.9390	3929.722	246344.485	3086.4042	55.5536
3/4	197.1354	3937.562	247082.047	3092.5615	55.6090
13/16	197.3317	3945.410	247821.072	3098.7251	55.6644
7/8	197.5281	3953.265	248561.574	3104.8948	55.7198
15/16	197.7244	3961.128	249309.650	3111.0707	55.7752

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
63 *in.*	197.9208	3969	250047	3117.2526	55.8306
1/16	198.1171	3976.878	250791.925	3124.4407	55.8850
1/8	198.3135	3984.765	251538.328	3129.6349	55.9414
3/16	198.5098	3992.660	252286.210	3135.8353	55.9967
1/4	198.7062	4000.562	253035.578	3142.0417	56.0521
5/16	198.9025	4008.472	253786.921	3148.7544	56.1075
3/8	199.0989	4016.390	254538.754	3154.4732	56.1629
7/16	199.2952	4024.316	255292.571	3160.7981	56.2183
1/2	199.4916	4032.25	256047.875	3166.9291	56.2737
9/16	199.6879	4040.191	256804.665	3173.1663	56.3291
5/8	199.8843	4048.140	257562.945	3179.4096	56.3845
11/16	200.0806	4056.097	258322.715	3185.6591	56.4398
3/4	200.2770	4064.062	259083.984	3191.9146	56.4952
13/16	200.4733	4072.035	259856.739	3193.1764	56.5506
7/8	200.6697	4080.015	260610.996	3204.4442	56.6060
15/16	200.8660	4088.003	261376.749	3210.7183	56.6614
64 *in.*	201.0624	4096	262144	3216.9984	56.7168
1/16	201.2587	4104.003	262912.749	3223.2847	56.7721
1/8	201.4551	4112.015	263683.000	3229.5770	56.8276
3/16	201.6514	4120.035	264454.153	3235.8746	56.8829
1/4	201.8478	4128.062	265228.015	3242.1782	56.9383
5/16	202.0441	4136.097	266102.777	3248.4936	56.9937
3/8	202.2405	4144.140	266779.051	3254.8030	57.0491
7/16	202.4368	4152.191	267557.633	3261.1311	57.1045
1/2	202.6332	4160.25	268336.125	3267.4603	57.1599
9/16	202.8295	4168.316	269054.927	3273.7957	57.2153
5/8	203.0259	4176.390	269899.242	3280.1372	57.2707
11/16	203.2222	4184.472	270683.071	3286.4875	57.3261
3/4	203.4186	4192.562	271468.422	3292.8385	57.3815
13/16	203.6149	4200.650	272248.153	3299.1935	57.4368
7/8	203.8113	4208.765	273043.668	3305.5645	57.4922
15/16	204.0076	4216.878	273814.092	3311.9367	57.5476
65 *in.*	204.2040	4225	274625	3318.3151	57.6030
1/16	204.4003	4233.128	275417.949	3324.7495	57.6584
1/8	204.5917	4241.265	276212.422	3331.0900	57.7138
3/16	204.7930	4249.410	277193.283	3337.9857	57.7691
1/4	204.9894	4257.562	277805.953	3343.8875	57.8245
5/16	205.1857	4265.722	278606.007	3350.2976	57.8799
3/8	205.3821	4273.890	279405.608	3356.7137	57.9353
7/16	205.5784	4282.066	280207.720	3363.1350	57.9907
1/2	205.7748	4290.25	281011.375	3369.5623	58.0461
9/16	205.9711	4298.441	281816.564	3375.9959	58.1015
5/8	206.1675	4306.640	282623.289	3382.4355	58.1569
11/16	206.3638	4314.847	283431.551	3388.8813	58.2122
3/4	206.5602	4323.062	284241.359	3395.3332	58.2676
13/16	206.7565	4331.275	285037.242	3401.7913	58.3230
7/8	206.9529	4339.515	285865.590	3408.2555	58.3784
15/16	207.1492	4347.753	286879.343	3414.7259	58.4338

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
66 *in.*	207.3456	4356	287496	3421.2024	58.4892
1/16	207.5419	4364.253	288313.523	3427.6850	58.5446
1/8	207.7383	4372.515	289132.594	3434.1737	58.5990
3/16	207.9346	4380.785	289953.213	3440.6676	58.6553
1/4	208.1310	4389.062	290775.390	3447.1676	58.7108
5/16	208.3273	4397.347	291592.211	3453.6758	58.7661
3/8	208.5237	4405.640	292424.395	3468.1901	58.8215
7/16	208.7200	4413.941	293251.231	3470.7096	58.8769
1/2	208.9164	4422.25	294079.625	3473.2351	58.9323
9/16	209.1127	4430.566	294899.576	3479.7669	58.9877
5/8	209.3091	4438.890	295741.086	3486.3047	59.0431
11/16	209.5054	4447.222	296574.157	3492.8487	59.0984
3/4	209.7018	4455.562	297408.797	3499.3987	59.1539
13/16	209.8981	4463.900	298744.325	3506.4550	59.2092
7/8	210.0945	4472.265	299082.762	3512.5174	59.2646
15/16	210.2908	4480.628	299922.097	3519.0060	59.3200
67 *in.*	210.4872	4489	300763	3525.6606	59.3754
1/16	210.6835	4497.378	301605.472	3532.2414	59.4308
1/8	210.8799	4505.765	302449.516	3538.8283	59.4862
3/16	211.0762	4514.160	303295.131	3545.4200	59.5415
1/4	211.2726	4522.562	304142.328	3552.0185	59.5969
5/16	211.4689	4530.972	304986.093	3558.6249	59.6523
3/8	211.6653	4539.390	305841.442	3565.2374	59.7077
7/16	211.8616	4547.816	306893.366	3571.8550	59.7631
1/2	212.0580	4556.25	307546.875	3578.4787	59.8185
9/16	212.2543	4564.691	308402.462	3585.1086	59.8739
5/8	212.4507	4573.140	309258.633	3591.7446	59.9293
11/16	212.6470	4581.597	310045.532	3598.8868	59.9847
3/4	212.8434	4590.062	310976.734	3605.0350	60.0401
13/16	213.0397	4598.535	311839.161	3611.6895	60.0954
7/8	213.2361	4607.015	312701.184	3618.3500	60.1508
15/16	213.4324	4615.503	313565.796	3625.0168	60.2062
68 *in.*	213.6288	4624	314432	3631.6896	60.2616
1/16	213.8251	4632.503	315299.796	3638.3686	60.3169
1/8	214.0215	4641.015	316169.187	3645.0536	60.3723
3/16	214.2178	4649.535	317040.174	3651.7439	60.4277
1/4	214.4142	4658.062	317912.766	3658.4402	60.4831
5/16	214.6105	4666.597	318785.948	3665.1448	60.5385
3/8	214.8069	4675.140	319662.738	3671.8554	60.5939
7/16	215.0032	4683.691	320780.130	3678.5762	60.6493
1/2	215.1996	4692.25	321419.125	3685.2931	60.7047
9/16	215.3959	4700.816	322459.724	3692.0212	60.7601
5/8	215.5923	4709.390	323181.930	3698.7554	60.8155
11/16	215.7886	4717.972	324065.743	3703 9957	60.8708
3/4	215.9850	4726.562	324951.172	3712.2421	60.9262
13/16	216.1813	4735.160	325837.204	3718.9948	60.9816
7/8	216.3777	4743.765	326726.977	3725.7535	61.0371
15/16	216.5748	4752.378	327617.120	3732.5184	61.0924

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
69 *in.*	216.7704	4761	328509	3739.2894	61.1478
1/16	216.9667	4769.628	329402.495	3745.8166	61.2032
1/8	217.1631	4778.265	330297.609	3752.3498	61.2586
3/16	217.3594	4786.910	331194.243	3759.6382	61.3139
1/4	217.5558	4795.562	332092.703	3766.4327	61.3693
5/16	217.7521	4804.222	332715.428	3773.2355	61.4247
3/8	217.9485	4812.890	333894.285	3780.0443	61.4801
7/16	218.1448	4821.566	334797.517	3786.8628	61.5355
1/2	218.3412	4830.25	335702.375	3793.6783	61.5909
9/16	218.5375	4838.941	336508.861	3800.5191	61.6463
5/8	218.7339	4847.640	337516.977	3807.3369	61.7017
11/16	218.9302	4856.347	338426.718	3814.2781	61.7571
3/4	219.1266	4865.062	339338.109	3821.0200	61.8125
13/16	219.3229	4873.785	340241.122	3827.8708	61.8678
7/8	219.5193	4882.515	341165.778	3834.7277	61.9233
15/16	219.7156	4891.253	341982.069	3841.5908	61.9786
70 *in.*	219.9120	4900	343000	3848.4600	62.0341
1/16	220.1083	4908.753	343919.570	3855.8353	62.0893
1/8	220.3047	4917.515	344840.781	3862.2167	62.1448
3/16	220.5010	4926.285	345759.635	3869.1033	62.2001
1/4	220.6974	4935.062	346688.141	3875.9960	62.2555
5/16	220.8937	4943.847	347514.284	3882.8969	62.3109
3/8	221.0901	4952.640	348542.082	3889.8039	62.3663
7/16	221.2864	4961.441	349471.528	3896.7211	62.4217
1/2	221.4828	4970.25	350402.625	3903.6343	62.4771
9/16	221.6791	4979.066	351335.372	3910.5588	62.5325
5/8	221.8755	4987.890	352259.774	3917.4893	62.5879
11/16	222.0718	4996.722	353205.828	3924.4260	62.6432
3/4	222.2682	5005.562	354143.547	3931.3687	62.6986
13/16	222.4645	5014.410	355182.915	3938.3177	62.7541
7/8	222.6609	5023.265	356023.949	3945.2728	62.8094
15/16	222.8572	5032.128	356966.643	3952.2341	62.8648
71 *in.*	223.0536	5041	357911	3959.2014	62.9202
1/16	223.2499	5049.878	358857.019	3966.1749	62.9756
1/8	223.4463	5058.765	359804.703	3973.1545	63.0301
3/16	223.6426	5067.660	360754.053	3980.1393	63.0863
1/4	223.8390	5076.562	361705.078	3987.1301	63.1417
5/16	224.0353	5085.472	362657.764	3994.1292	63.1971
3/8	224.2317	5094.390	363612.129	4001.1344	63.2525
7/16	224.4380	5103.316	364568.165	4008.1447	63.3079
1/2	224.6244	5112.25	365525.875	4015.1611	63.3633
9/16	224.8207	5121.191	366485.259	4022.1837	63.4187
5/8	225.0171	5130.140	367446.320	4029.2124	63.4741
11/16	225.2134	5139.097	368409.059	4036.2473	63.5295
3/4	225.4098	5148.062	369373.484	4043.2882	63.5849
13/16	225.6061	5157.035	370339.583	4050.3354	63.6402
7/8	225.8025	5166.015	371307.371	4057.3888	63.6956
15/16	225.9988	5175.003	372276.843	4064.4481	63.7511

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
72 *in.*	226.1952	5184	373248	4071.5136	63.8064
1/16	226.3915	5193.003	374220.843	4078.5853	63.8617
1/8	226.5879	5202.015	375195.375	4085.6631	63.9171
3/16	226.7842	5211.035	376161.596	4092.7460	63.9725
1/4	226.9806	5220.062	377149.515	4099.8350	64.0279
5/16	227.1769	5229.097	378129.140	4106.9323	64.0833
3/8	227.3733	5238.140	379110.425	4114.0356	64.1367
7/16	227.5696	5247.191	380093.427	4121.1442	64.1941
1/2	227.7660	5256.25	381078.125	4128.2587	64.2495
9/16	227.9623	5265.316	382063.521	4135.3795	64.3049
5/8	228.1587	5274.390	383052.617	4142.5064	64.3603
11/16	228.3550	5283.472	384192.414	4149.6394	64.4157
3/4	228.5514	5292.562	385033.921	4156.7785	64.4711
13/16	228.7477	5301.650	386026.397	4163.9239	64.5264
7/8	228.9441	5310.765	387022.043	4171.0753	64.5818
15/16	229.1404	5319.878	388747.938	4178.2329	64.6372
73 *in.*	229.3368	5329	389017	4185.3966	64.6926
1/16	229.5331	5338.128	390017.042	4192.5665	64.7470
1/8	229.7295	5347.265	391018.797	4199.7424	64.8034
3/16	229.9258	5356.410	392013.264	4206.9230	64.8587
1/4	230.1222	5365.562	393027.453	4214.1107	64.9141
5/16	230.3185	5374.722	394034.350	4221.3027	64.9695
3/8	230.5149	5383.890	395042.972	4228.5077	65.0249
7/16	230.7112	5393.066	396053.313	4235.7109	65.0803
1/2	230.9076	5402.25	397065.375	4242.9271	65.1357
9/16	231.1039	5411.441	398079.157	4250.1461	65.1911
5/8	231.3003	5420.640	399094.664	4257.3711	65.2465
11/16	231.4966	5429.847	400111.865	4264.6023	65.3018
3/4	231.6930	5439.062	401130.359	4271.8396	65.3572
13/16	231.8893	5448.275	402150.805	4279.0831	65.4126
7/8	232.0857	5457.515	403173.964	4286.3327	65.4650
15/16	232.2820	5466,753	404198.116	4293.5885	65.5234
74 *in.*	232.4784	5476	405224	4300.8504	65.5788
1/16	232.6747	5485.253	406251.616	4308.1185	65.6341
1/8	232.8711	5494.515	407280.968	4315.3926	65.6895
3/16	233.0674	5503.785	408312.057	4322.1719	65.7449
1/4	233.2638	5513.062	409344.890	4329.9572	65.8003
5/16	233.4601	5522.347	410379.456	4337.2508	65.8557
3/8	233.6565	5531.640	411415.769	4344.5505	65.9111
7/16	233.8528	5540.941	412453.775	4351.8551	65.9665
1/2	234.0492	5550.25	413493.625	4359.1663	66.0219
9/16	234.2455	5559.566	414535.169	4366.4835	66.0773
5/8	234.4419	5568.890	415578.461	4373.8067	66.1327
11/16	234.6382	5578.222	416613.500	4381.1361	66.1880
3/4	234.8346	5587.562	417670.296	4388.4715	66.2434
15/16	235.0309	5596.900	418719.087	4396.3132	66.2988
7/8	235.2273	5606.265	419769.136	4403.1610	66.3542
15/16	235.4236	5615.628	420821.190	4410.5150	66.40

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
75 *in.*	235.6200	5625	421875	4417.8750	66.4650
1/16	235.8163	5634.378	422930.566	4425.2412	66.5204
1/8	236.0127	5643.765	423987.890	4432.6135	66.5758
3/16	236.2090	5653.160	424046.975	4439.9910	66.6311
1/4	236.4054	5662.562	426107.828	4447.3745	66.6865
5/16	236.6017	5671.972	427170.436	4454.7663	66.7419
3/8	236.7981	5681.390	428234.816	4462.1642	66.7973
7/16	236.9944	5690.816	429300.952	4469.5672	66.8527
1/2	237.1908	5700.25	430368.875	4476.9763	66.9081
9/16	237.3871	5709.691	431438.541	4484.3916	66.9635
5/8	237.5835	5719.140	432510.007	4491.8130	67.0189
11/16	237.7798	5728.597	433583.230	4499.2406	67.0743
3/4	237.9762	5738.062	434658.234	4506.6742	67.1297
13/16	238.1725	5747.525	435734.246	4514.1141	67.1850
7/8	238.3689	5757.015	436813.558	4521.5600	67.2404
15/16	238.5652	5766.503	436893.889	4529.9622	67.2958
76 *in.*	238.7616	5776	438976	4536.4704	67.3512
1/16	238.9579	5785.503	440059.990	4543.9333	67.4066
1/8	239.1543	5795.015	441145.564	4551.4023	67.4619
3/16	239.3506	5804.535	442233.017	4558.8794	67.5173
1/4	239.5470	5814.062	443322.265	4566.3626	67.5727
5/16	239.7433	5823.597	444413.291	4573.8526	67.6281
3/8	239.9397	5833.140	445506.113	4581.3486	67.6835
7/16	240.1360	5842.691	446600.724	4588.8493	67.7389
1/2	240.3324	5852.25	447697.125	4596.3571	67.7943
9/16	240.5287	5861.816	448795.318	4603.8706	67.8497
5/8	240.7251	5871.390	449895.304	4611.3902	67.9051
11/16	240.9214	5880.972	450997.086	4618.9159	67.9605
3/4	241.1178	5890.562	452100.671	4626.4477	68.0159
13/16	241.3141	5900.150	453205.279	4633.9858	68.0712
7/8	241.5105	5909.765	454313.230	4641.5299	68.1266
15/16	241.7068	5919.378	455422.214	4649.0802	68.1821
77 *in.*	241.9032	5929	456533	4656.6366	68.2374
1/16	242.0995	5938.628	457645.389	4664.1992	68.2928
1/8	242.2959	5948.265	458759.984	4671.7678	68.3482
3/16	242.4922	5957.910	459820.610	4679.3416	68.4035
1/4	242.6886	5967.562	460994.203	4686.9215	68.4589
5/16	242.8849	5977.222	462114.022	4694.5097	68.5143
3/8	243.0813	5986.890	463235.660	4702.1039	68.5697
7/16	243.2776	5996.566	464359.110	4709.7033	68.6251
1/2	243.4740	6006.25	465484.375	4717.3087	68.6805
9/16	243.6703	6015.941	466611.474	4724.9204	68.7359
5/8	243.8667	6025.640	467740.351	4732.5381	68.7913
11/16	244.0630	6035.347	468871.166	4740.1620	68.8467
3/4	244.2594	6045.062	470003.899	4747.7920	68.9021
13/16	244.4557	6054.775	471027.187	4755.3892	68.9574
7/8	244.6521	6064.515	472274.152	4763.0705	69.0128
15/16	244.8484	6074.253	473413.963	4771.1030	69.0682

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
78 in.	245.0443	6084	474552	4778.3736	69.1236
1/16	245.2411	6093.753	475693.663	4786.0344	69.1790
1/8	245.4375	6103.515	476837.156	4793.7012	69.2343
3/16	245.6338	6113.285	477982.478	4801.3732	69.2897
1/4	245.8302	6123.062	479129.640	4809.0512	69.3451
5/16	246.0265	6132.847	480277.627	4817.1375	69.4006
3/8	246.2229	6142.640	481429.457	4824.4299	69.4559
7/16	246.4192	6152.441	482582.114	4832.1275	69.5113
1/2	246.6156	6162.25	483736.625	4839.8311	69.5667
9/16	246.8119	6172.066	484752.966	4847.5409	69.6221
5/8	247.0083	6181.890	486051.148	4855.2568	69.6775
11/16	247.2046	6191.722	487211.272	4862.9789	69.7329
3/4	247.4010	6201.562	488373.047	4870.7071	69.7883
13/16	247.5973	6211.400	489736.071	4878.4415	69.8437
7/8	247.7937	6221.265	490702.324	4886.1820	69.8991
15/16	247.9900	6231.128	491769.737	4893.9287	69.9544
79 in.	248.1864	6241	493039.	4901.6814	70.0098
1/16	248.3827	6250.878	494210.113	4909.4403	70.0652
1/8	248.5791	6260.765	495383.078	4917.2053	70.1206
3/16	248.7754	6270.660	496557.896	4924.9755	70.1760
1/4	248.9718	6280.562	497734.578	4932.7517	70.2314
5/16	249.1681	6290.472	498913.108	4940.5302	70.2867
3/8	249.3645	6300.390	500093.504	4948.3268	70.3421
7/16	249.5608	6310.316	501275.757	4956.1225	70.3975
1/2	249.7572	6320.25	502459.875	4963.9243	70.4529
9/16	249.9535	6330.191	503645.853	4971.7319	70.5083
5/8	250.1499	6340.140	504833.695	4979.5456	70.5637
11/16	250.3462	6350.097	506023.401	4987.3663	70.6191
3/4	250.5426	6360.062	507214.992	4995.1930	70.6745
13/16	250.7389	6370.025	508407.621	5003.0316	70.7298
7/8	250.9353	6380.015	509603.746	5010.8642	70.7853
15/16	251.1316	6390.003	510800.936	5018.7091	70.8406
80 in.	251.3280	6400	512000	5026.5600	70.8960
1/16	251.5243	6410.003	513200.937	5034.4171	70.9513
1/8	251.7207	6420.015	514403.750	5042.2803	71.0068
3/16	251.9170	6430.035	515608.439	5050.1486	71.0622
1/4	252.1134	6440.062	516815.916	5058.0230	71.1176
5/16	252.3097	6450.097	518033.463	5065.9027	71.1729
3/8	252.5061	6460.140	519233.901	5073.7944	71.2283
7/16	252.7024	6470.191	520446.020	5081.6883	71.2837
1/2	252.8988	6480.25	521660.125	5089.5883	71.3391
9/16	253.0951	6490.316	522876.114	5097.4941	71.3945
5/8	253.2915	6500.390	524093.992	5105.4060	71.4499
11/16	253.4878	6510.472	525313.756	5113.3242	71.5053
3/4	253.6842	6520.562	526535.422	5121.2487	71.5607
13/16	253.8805	6530.660	527758.969	5129.1855	71.6161
7/8	254.0769	6540.765	528984.413	5137.1173	71.6715
15/16	254.2732	6550.878	530210.761	5145.0603	71.726

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
81 in.	254.4696	6561	531441	5153.0094	71.7832
1/16	254.6659	6571.128	532672.136	5160.9647	71.8376
1/8	254.8623	6581.265	533903.172	5168.9260	71.8930
3/16	255.0586	6591.410	535140.107	5176.8925	71.9484
1/4	255.2550	6601.562	536376.953	5184.8651	72.0037
5/16	255.4513	6611.722	537615.694	5192.8460	72.0591
3/8	255.6477	6621.890	538856.347	5200.8329	72.1145
7/16	255.8440	6632.066	540098.907	5208.8250	72.1699
1/2	256.0404	6642.25	541343.375	5216.8231	72.2253
9/16	256.2367	6652.441	542589.751	5224.8271	72.2807
5/8	256.4331	6662.640	543838.039	5232.8371	72.3361
11/16	256.6294	6672.847	545088.238	5240.8568	72.3915
3/4	256.8258	6683.062	546340.359	5248.8772	72.4469
13/16	257.0221	6693.285	547594.387	5256.9061	72.5023
7/8	257.2105	6703.515	548850.339	5264.9411	72.5577
15/16	257.4148	6713.753	550108.211	5272.9828	72.6130
82 in.	257.6112	6724	551368	5281.0296	72.6684
1/16	257.8075	6734.253	552629.710	5289.0781	72.7237
1/8	258.0039	6744.515	553863.343	5297.1426	72.7792
3/16	258.2002	6754.785	555158.900	5305.2073	72.8346
1/4	258.3966	6765.062	556426.390	5313.2780	72.8901
5/16	258.5929	6775.347	557695.799	5321.3570	72.9453
3/8	258.7893	6785.640	558967.144	5329.4421	73.0007
7/16	258.9856	6795.941	559140.118	5337.5324	73.0561
1/2	259.1820	6806.25	561515.625	5345.6287	73.1115
9/16	259.3783	6816.566	563292.769	5353.7309	73.1669
5/8	259.5747	6826.890	564071.836	5361.8391	73.2224
11/16	259.7710	6837.222	565352.844	5369.9543	73.2777
3/4	259.9674	6847.562	566635.797	5378.0755	73.3330
13/16	260.1637	6857.910	567900.480	5386.2026	73.3885
7/8	260.3601	6868.265	569207.511	5394.3358	73.4438
15/16	260.5564	6878.628	570496.284	5402.4552	73.4993
83 in.	260.7528	6889	571787	5410.6206	73.5546
1/16	260.9491	6899.378	573079.659	5418.7722	73.6101
1/8	261.1455	6909.765	574374.265	5426.9299	73.6653
3/16	261.3418	6920.160	575670.818	5435.0928	73.7208
1/4	261.5382	6930.562	576969.328	5443.2617	73.7761
5/16	261.7345	6940.972	578269.769	5451.4389	73.8315
3/8	261.9309	6951.390	579572.191	5459.6222	73.8869
7/16	262.1272	6961.816	580876.556	5467.8106	73.9423
1/2	262.3236	6972.25	582182.875	5476.0051	73.9977
9/16	262.5199	6982.691	583491.150	5484.2054	74.0531
5/8	262.7163	6993.140	584801.382	5492.4118	74.1085
11/16	262.9126	7003.597	586113.574	5500.6252	74.1639
3/4	263.1090	7014.062	587427.734	5508.8446	74.2193
13/16	263.3053	7024.535	589067.048	5517.0699	74.2747
7/8	263.5017	7035.015	590061.933	5525.3012	74.3301
15/16	263.6980	7045.503	591381.983	5533.5386	74.3854

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
84 *in.*	263.8944	7056	592704	5541.7824	74.4408
1/16	264.0907	7065.503	593943.922	5550.0322	74.4962
1/8	264.2871	7077.015	595353.937	5558.2881	74.5516
3/16	264.4834	7087.535	596794.862	5566.5491	74.6070
1/4	264.6798	7098.062	598011.765	5574.8162	74.6624
5/16	264.8761	7108.597	599343.635	5583.0916	74.7177
3/8	265.0725	7119.140	600677.488	5591.3730	74.7731
7/16	265.2688	7129.691	602012.317	5599.6596	74.8285
1/2	265.4652	7140.25	603351.125	5607.9523	74.8839
9/16	265.6615	7150.816	604690.912	5616.2508	74.9393
5/8	265.8579	7161.390	606032.679	5624.5554	74.9947
11/16	266.0542	7171.972	607376.429	5632.8662	75.0601
3/4	266.2506	7182.562	608722.172	5641.1845	75.1055
13/16	266.4469	7193.160	609969.891	5649.5071	75.1608
7/8	266.6433	7203.765	611419.605	5657.8357	75.2162
15/16	266.8396	7214.378	612771.408	5666.1723	75.2716
85 *in.*	267.0360	7225	614125	5674.5150	75.3269
1/16	267.2323	7235.628	615480.693	5682.8630	75.3824
1/8	267.4287	7246.265	616839.359	5691.2170	75.4378
3/16	267.6250	7256.910	618198.029	5699.5762	75.4931
1/4	267.8214	7267.562	619559.703	5707.9415	75.5486
5/16	268.0177	7278.222	620923.365	5716.3151	75.6039
3/8	268.2141	7288.890	622289.035	5724.6947	75.6593
7/16	268.4104	7299.566	623656.713	5733.0795	75.7147
1/2	268.6068	7310.25	625026.375	5741.4703	75.7701
9/16	268.8031	7320.941	626398.048	5749.8670	75.8255
5/8	268.9997	7331.640	627771.726	5758.2697	75.8809
11/16	269.1958	7342.347	629147.409	5766.6794	75.9363
3/4	269.3922	7353.062	630525.109	5775.0952	75.9917
13/16	269.5885	7363.785	631904.808	5783.5168	76.0471
7/8	269.7849	7374.515	633286.527	5791.9445	76.1025
15/16	269.9812	7385.253	634670.257	5800.3784	76.1578
86 *in.*	270.1776	7396	636056	5808.8184	76.2132
1/16	270.3739	7406.753	637443.757	5817.2651	76.2686
1/8	270.5703	7417.515	638833.531	5825.7168	76.3240
3/16	270.7666	7428.285	640325.320	5834.1742	76.3794
1/4	270.9630	7439.062	641619.140	5842.6376	76.4347
5/16	271.1593	7449.847	643014.971	5851.1093	76.4901
3/8	271.3557	7460.640	644412.832	5859.5871	76.5455
7/16	271.5520	7471.441	645812.722	5868.0701	76.6009
1/2	271.7484	7482.25	647214.625	5876.5591	76.6563
9/16	271.9447	7493.066	648078.560	5885.0540	76.7117
5/8	272.1411	7503.890	650024.523	5893.5549	76.7671
11/16	272.3374	7514.722	651432.515	5902.0620	76.8225
3/4	272.5338	7525.562	652842.547	5910.5767	76.8779
13/16	272.7301	7536.410	654254.601	5919.0965	76.9333
7/8	272.9265	7547.265	655668.699	5927.6224	76.9887
15/16	273.1228	7558.128	656984.831	5936.1545	77.0441

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
87 *in.*	273.3192	7569	658503	5944.6926	77.0884
1/16	273.5155	7579.878	659913.206	5953.2369	77.1549
1/8	273.7119	7590.765	661345.453	5961.7873	77.2107
3/16	273.9082	7601.660	662769.740	5970.3429	77.2655
1/4	274.1046	7612.562	664196.078	5978.9045	77.3210
5/16	274.3009	7623.472	665618.451	5987.4749	77.3763
3/8	274.4973	7634.390	667054.878	5996.0504	77.4317
7/16	274.6936	7645.316	668487.353	6004.6315	77.4871
1/2	274.8900	7656.25	669921.875	6013.2187	77.5425
9/16	275.0863	7667.191	671368.487	6021.8117	77.5979
5/8	275.2827	7678.140	672797.070	6030.4108	77.6533
11/16	275.4790	7689.097	674237.746	6039.0169	77.7086
3/4	275.6754	7700.062	675680.484	6047.6290	77.7640
13/16	275.8717	7711.035	677125.269	6056.2470	77.8194
7/8	276.0681	7722.015	678572.121	6064.8710	77.8748
15/16	276.2644	7733.003	680021.030	6073.5013	77.9302
88 *in.*	276.4608	7744	681472	6082.1376	77.9855
1/16	276.6571	7755.003	682925.031	6090.7801	78.0409
1/8	276.8535	7766.015	684380.125	6099.4287	78.0964
3/16	277.0498	7777.035	685837.283	6108.0824	78.1518
1/4	277.2462	7788.062	687296.516	6116.7422	78.2071
5/16	277.4425	7799.097	688757.807	6125.4103	78.2625
3/8	277.6389	7810.140	690221.175	6134.0844	78.3179
7/16	277.8352	7821.191	691686.614	6144.2637	78.3733
1/2	278.0316	7832.25	693154.125	6151.4491	78.4287
9/16	278.2279	7843.316	694623.708	6160.1403	78.4841
5/8	278.4243	7854.390	696095.367	6169.8376	78.5395
11/16	278.6206	7865.472	697569.001	6177.5418	78.5949
3/4	278.8170	7876.562	699044.922	6186.2521	78.6503
13/16	279.0133	7887.660	700522.883	6194.9683	78.7057
7/8	279.2097	7898.765	702002.793	6203.6905	78.7610
15/16	279.4060	7909.878	703484.744	6212.4189	78.8164
89 *in.*	279.6024	7921	704969.	6221.1534	78.8718
1/16	279.7987	7932.128	706455.230	6229.8941	78.9272
1/8	279.9951	7943.265	707943.547	6238.6408	78.9826
3/16	280.1914	7954.410	709434.951	6247.3927	79.0379
1/4	280.3878	7965.562	710926.453	6256.1507	79.0934
5/16	280.5841	7976.722	712421.027	6264.9170	79.1487
3/8	280.7805	7987.890	713907.722	6273.6893	79.2041
7/16	280.9768	7999.066	715405.501	6282.4668	79.2595
1/2	281.1732	8010.25	716917.375	6291.2503	79.3149
9/16	281.3695	8021.441	718420.345	6300.0397	79.3703
5/8	281.5659	8032.640	719925.414	6308.8351	79.4258
11/16	281.7622	8043.847	721432.542	6317.6375	79.4811
3/4	281.9586	8055.062	722951.859	6326.4460	79.5364
13/16	282.1549	8066.205	724253.290	6335.2603	79.5919
7/8	282.3513	8077.515	725966.714	6344.0807	79.6473
15/16	282.5476	8088.753	727482.304	6352.9073	79.7026

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square
90 *in.*	282.7440	8100	729000	6361.7406	79.7308
1/16	282.9403	8111.253	730019.894	6370.5288	79.8014
1/8	283.1367	8122.515	731041.718	6379.3188	79.8720
3/16	283.3330	8133.785	732065.644	6388.1106	79.9426
1/4	283.5294	8145.062	733091.599	6396.9036	80.0132
5/16	283.7257	8156.347	734119.742	6405.6984	80.0839
3/8	283.9221	8167.640	735150.519	6414.4949	80.1545
7/16	284.1184	8178.941	736183.013	6423.2930	80.2251
1/2	284.3148	8190.25	741217.625	6432.0923	80.2957
9/16	284.5111	8201.566	742254.357	6440.8931	80.3663
5/8	284.7075	8212.890	744293.216	6449.6959	80.4369
11/16	284.9038	8224.222	745324.147	6458.5043	80.5075
3/4	285.1002	8235.562	747377.297	6467.3167	80.5781
13/16	285.2965	8246.910	748322.323	6477.1292	80.6487
7/8	285.4929	8258.265	750469.385	6486.0413	80.7193
15/16	285.6892	8269.628	752919.378	6494.9566	80.7899
91 *in.*	285.8856	8281	753571	6503.8974	80.8605
1/16	286.0819	8292.378	755124.753	6512.8344	80.9306
1/8	286.2783	8303.765	756680.840	6521.7775	80.7500
3/16	286.4746	8315.160	758239.661	6530.7238	80.8184
1/4	286.6710	8326.562	759798.823	6539.6701	80.8858
5/16	286.8673	8337.972	761361.123	6548.6427	80.9211
3/8	287.0637	8349.390	762925.566	6557.6114	80.9763
7/16	287.2600	8360.816	764492.149	6566.5857	81.0319
1/2	287.4564	8372.25	766060.875	6575.5651	81.0873
9/16	287.6527	8383.691	767631.744	6584.5511	81.1427
5/8	287.8491	8395.140	769204.757	6593.5431	81.1981
11/16	288.0454	8406.597	770779.917	6602.5443	81.2535
3/4	288.2418	8418.062	772357.234	6611.5462	81.3089
13/16	288.4381	8429.535	773935.773	6620.5569	81.3643
7/8	288.6345	8441.015	775518.308	6629.5736	81.4197
15/16	288.8308	8452.503	777102.077	6638.5967	81.4750
92 *in.*	289.0272	8464	778688	6647.6258	81.5304
1/16	289.2235	8475.503	780276.077	6656.6609	81.5858
1/8	289.4199	8487.015	781866.312	6665.7021	81.6412
3/16	289.6162	8498.535	783448.704	6674.7485	81.6966
1/4	289.8125	8510.062	785053.265	6683.8010	81.7519
5/16	290.0089	8521.597	786649.978	6692.8618	81.8073
3/8	290.2053	8533.140	788248.863	6701.9286	81.8627
7/16	290.4016	8544.691	789849.911	6711.0001	81.9181
1/2	290.5980	8556.25	791453.125	6720.0787	81.9735
9/16	290.7943	8567.816	793057.505	6729.6628	82.0289
5/8	290.9907	8579.390	794666.054	6738.2530	82.0843
11/16	291.1870	8590.972	796275.773	6747.3487	82.1397
3/4	291.3834	8602.562	797887.672	6756.4525	82.1950
13/16	291.5797	8614.160	799501.734	6765.5614	82.25505
7/8	291.7761	8625.765	801117.980	6774.6763	82.30959
15/16	291.9724	8637.378	802736.411	6783.7975	82.3641

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
93 *in.*	292.1688	8649	804357	6792.9248	82.4166
1/16	292.3651	8660.628	805979.777	6802.0581	82.4720
1/8	292.5615	8672.265	807604.734	6811.1974	82.5274
3/16	292.7578	8683.910	809231.872	6820.3420	82.5828
1/4	292.9542	8695.562	810861.203	6829.4927	82.6382
5/16	293.1505	8707.222	812492.708	6838.6517	82.6935
3/8	293.3469	8718.890	814126.410	6847.8167	82.7489
7/16	293.5432	8730.566	815762.298	6856.9869	82.8043
1/2	293.7396	8742.25	817400.375	6866.1631	82.8597
9/16	293.9359	8753.941	819040.642	6875.3454	82.9151
5/8	294.1323	8765.640	820683.101	6884.5338	82.9705
11/16	294.3286	8777.347	822328.353	6893.7337	83.0259
3/4	294.5350	8789.062	823974.610	6902.9296	83.0813
13/16	294.7213	8800.785	825623.652	6912.1366	83.1367
7/8	294.9177	8812.515	827274.903	6921.3497	83.1921
15/16	295.1140	8824.253	828928.351	6930.5691	83.2475
94 *in.*	295.3104	8836	830584	6939.7946	83.3026
1/16	295.5067	8847.753	832041.851	6949.5261	83.3582
1/8	295.7031	8859.515	833901.906	6958.2636	83.4136
3/16	295.8994	8871.285	835564.165	6968.0064	83.4690
1/4	296.0958	8883.062	837228.640	6976.7552	83.5244
5/16	296.2921	8894.847	838885.214	6986.0123	83.5797
3/8	296.4885	8906.640	840564.207	6995.2755	83.6351
7/16	296.6848	8918.441	842235.209	7004.5439	83.6905
1/2	296.8812	8930.25	843908.625	7013.8183	83.7459
9/16	297.0775	8942.066	845621.988	7023.0988	83.8013
5/8	297.2739	8953.890	847261.898	7032.3853	83.8567
11/16	297.4702	8965.722	848931.858	7041.6784	83.9121
3/4	297.6666	8977.562	850624.047	7050.9775	83.9675
13/16	297.8629	8989.410	852206.445	7060.2827	84.0229
7/8	298.0593	9001.265	853995.074	7069.5940	84.0783
15/16	298.2556	9013.128	856491.925	7075.9116	84.1336
95 *in.*	298.4520	9025	857375	7088.2352	84.1890
1/16	298.6483	9036.878	859063.300	7097.5738	84.2444
1/8	298.8447	9048.765	860763.828	7106.8005	84.2998
3/16	299.0400	9060.660	862461.583	7116.7415	84.3552
1/4	299.2374	9072.562	864161.578	7125.5885	84.4106
5/16	299.4337	9084.472	865863.794	7134.9443	84.4660
3/8	299.6301	9096.390	867568.253	7144.3052	84.5213
7/16	299.8264	9108.316	869274.947	7153.6717	84.5767
1/2	300.0228	9120.25	870983.875	7163.0443	84.6321
9/16	300.2191	9132.191	872695.140	7172.4230	84.6875
5/8	300.4155	9144.140	874408.445	7181.8077	84.7429
11/16	300.6118	9156.097	876124.009	7191.1989	84.7983
3/4	300.8082	9168.062	877841.984	7200.5962	84.8537
13/16	301.0045	9180.035	879566.903	7209.9990	84.9091
7/8	301.2009	9192.015	881284.495	7219.4090	84.9645
15/16	301.3972	9204.003	883009.124	7228.8240	85.0199

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
96 *in.*	301.5936	9216	884736	7238.2466	85.0752
1/16	301.7899	9228.003	886465.124	7247.6741	85.1306
1/8	301.9863	9248.015	888965.499	7257.1083	85.1860
3/16	302.1826	9252.035	889930.126	7266.5474	85.2414
1/4	302.3790	9264.062	891666.015	7275.9926	85.2967
5/16	302.5753	9276.097	893401.160	7285.4461	85.3521
3/8	302.7717	9288.140	894944.550	7294.9056	85.4075
7/16	302.9680	9300.191	896687.208	7304.3703	85.4629
1/2	303.1644	9312.25	898632.125	7313.8411	85.5183
9/16	303.3607	9324.316	900379.302	7323.3179	85.5737
5/8	303.5571	9336.390	902128.742	7332.8008	85.6291
11/16	303.7534	9348.472	903786.444	7342.2902	85.6845
3/4	303.9498	9360.562	905634.422	7351.7857	85.7399
13/16	304.1461	9372.660	907397.655	7361.2873	85.7952
7/8	304.3425	9384.765	909149.167	7370.7949	85.8506
15/16	304.5388	9396.878	910909.948	7380.3088	85.9060
97 *in.*	304.7352	9409	912673	7389.8288	85.9614
1/16	304.9315	9421.128	914438.324	7399.3548	86.0167
1/8	305.1279	9433.265	916205.921	7408.8868	86.0722
3/16	305.3242	9445.410	916974.794	7418.6241	86.1276
1/4	305.5206	9457.562	919747.953	7427.9675	86.1830
5/16	305.7169	9469.722	921522.380	7437.5192	86.2383
3/8	305.9133	9481.890	923299.097	7447.0769	86.2937
7/16	306.1096	9494.066	924078.095	7456.6398	86.3491
1/2	306.3060	9506.25	926859.375	7466.2087	86.4045
9/16	306.5023	9518.441	928642.939	7475.7837	86.4599
5/8	306.6987	9530.640	930428.788	7485.3648	86.5153
11/16	306.8950	9542.847	932215.924	7494.9524	86.6570
3/4	307.0914	9555.062	934007.359	7504.5460	86.6626
13/16	307.2877	9567.285	935800.073	7514.1457	86.6814
7/8	307.4841	9579.515	937595.089	7523.7515	86.7368
15/16	307.6804	9591.753	939392.397	7533.3636	86.7922
98 *in.*	307.8768	9604	941192	7542.9818	86.8476
1/16	308.0731	9616.253	942993.898	7552.6060	86.9030
1/8	308.2695	9628.515	944789.093	7562.2362	86.9584
3/16	308.4658	9640.785	946604.587	7575.8717	87.0138
1/4	308.6622	9653.062	948413.390	7581.5132	87.0692
5/16	308.8585	9665.347	950224.485	7591.1630	87.1245
3/8	309.0549	9677.640	952037.894	7600.8189	87.1799
7/16	309.2512	9689.941	953852.606	7610.4800	87.2353
1/2	309.4476	9702.25	955671.625	7620.1471	87.2907
9/16	309.6439	9714.566	957591.730	7629.8203	87.3461
5/8	309.8403	9726.890	959314.585	7639.4995	87.4015
11/16	310.0366	9739.222	961139.530	7649.1853	87.4569
3/4	310.2330	9751.562	962966.797	7658.8771	87.5123
13/16	310.4293	9763.910	964956.366	7668.5750	87.5677
7/8	310.6257	9776.265	966628.261	7678.2790	87.6231
15/16	310.8220	9788.628	968362.471	7687.9893	87.6785

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
99 *in.*	311.0184	9801	970299	7697.7056	87.7333
1/16	311.2147	9813.378	972137.847	7707.4279	87.7892
1/8	311.4111	9825.765	973979.015	7717.1563	87.8446
3/16	311.6074	9838.160	975821.504	7726.8900	87.9001
1/4	311.8038	9850.562	977668.328	7736.6297	87.9554
5/16	312.0001	9862.972	979516.476	7746.3777	88.0107
3/8	312.1965	9875.390	981366.941	7756.1318	88.0661
7/16	312.3928	9887.816	983218.743	7765.8910	88.1215
1/2	312.5892	9900.25	985074.875	7775.6563	88.1769
9/16	312.7855	9912.691	986932.337	7785.4277	88.2323
5/8	312.9819	9925.140	988792.132	7795.2051	88.2877
11/16	313.0782	9937.597	990654.210	7804.9890	88.3431
3/4	313.3746	9950.062	992518.734	7814.7790	88.3985
13/16	313.5709	9962.535	994385.534	7824.5751	88.4539
7/8	313.7673	9975.015	996254.683	7834.3772	88.5093
15/16	313.9636	9987.503	998122.170	7844.1856	88.5646
100 *in.*	314.1600	10000	1000000	7854.0000	88.6200
1/4	314.9454	10050.062	1007518.765	7893.3190	88.8415
1/2	315.7308	10100.25	1015075.125	7932.7360	89.0631
3/4	316.5162	10150.562	1022669.171	7972.2120	89.2847
101 *in.*	317.3016	10201	1030301	8011.8652	89.5062
1/4	318.0870	10251.562	1037970.703	8051.5772	89.7278
1/2	318.8724	10302.25	1045678.37	8091.3870	89.9493
3/4	319.6578	10353.062	1053424.109	8131.2953	90.1709
102 *in.*	320.4432	10404	1061208	8171.3016	90.3924
1/4	321.2286	10455.062	1069030.140	8211.4060	90.6140
1/2	322.0140	10506.25	1076890.625	8251.6084	90.8355
3/4	322.7994	10557.562	1084789.546	8291.8696	91.0571
103 *in.*	323.5848	10609	1092727	8332.3085	91.2786
1/4	324.3702	10660.562	1100703.078	8372.8056	91.5002
1/2	325.1556	10712.25	1108717.375	8413.4008	91.7217
3/4	325.9410	10764.059	1116771.173	8454.0944	91.9433
104 *in.*	326.7264	10816	1124864	8494.8864	92.1648
1/4	327.5118	10868.062	1132995.526	8535.7760	92.3864
1/2	328.2972	10920.25	1141166.125	8576.7640	92.6079
3/4	329.0826	11032.562	1155660.921	8617.8504	92.8295
105 *in.*	329.8680	11025	1157625	8659.0348	93.0510
1/4	330.6534	11077.562	1165913.453	8700.3176	93.2726
1/2	331.4388	11130.25	1174241.375	8741.6980	93.4941
3/4	332.2242	11183.062	1182608.859	8783.1772	93.7157
106 *in.*	333.0096	11236	1191016	8824.7544	93.9372
1/2	334.5804	11342.25	1207949.625	8908.2028	94.3803
107 *in.*	336.1512	11449	1225043	8992.0444	94.8234
1/2	337.7220	11556.25	1242296.875	9076.2784	95.2665
108 *in.*	339.2928	11664	1259712	9160.9056	95.7096
1/2	340.8636	11772.25	1277289.125	9245.9248	96.1527
109 *in.*	342.4344	11881	1295029	9331.3372	96.5958
1/2	344.0052	11990.25	1312932.375	9417.1420	97.0389
110 *in.*	345.5760	12100	1331000	9503.3400	97.4820

A TABLE

CONTAINING

THE CIRCUMFERENCES & AREAS OF CIRCLES,

From 1 *to* 50 *Feet, advancing by an Inch;*

ALSO,

THE SIDE OF A SQUARE OF EQUAL AREA,

AND THE

Content of each in Imperial Gallons and Cubic Yards, at 1 *Foot in depth.*

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of — square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
1 *ft.*	3 1⅝	.7854	0 10⅝	4.8946	.0291
1	3 4⅝	.9217	0 11½	5.7440	.0341
2	3 8	1.0690	1 0⅝	6.6620	.0395
3	3 11	1.2271	1 1¼	7.6472	.0454
4	4 2⅛	1.3962	1 2⅛	8.7011	.0517
5	4 5⅜	1.5761	1 3	9.8222	.0583
6	4 8½	1.7671	1 3⅞	11.0125	.0654
7	4 11⅝	1.9689	1 4¾	12.2701	.0729
8	5 2¾	2.1816	1 5⅝	13.5957	.0808
9	5 5⅞	2.4052	1 6½	14.9892	.0890
10	5 9	2.6398	1 7½	16.4512	.0977
11	6 2¼	2.8852	1 8⅜	17.9025	.1068
2 *ft.*	6 3⅜	3.1416	1 9¼	19.5784	.1163
1	6 6½	3.4087	1 10⅛	21.2430	.1262
2	6 9⅝	3.6869	1 11	22.9767	.1365
3	7 0¾	3.9760	1 11⅞	24.7784	.1472
4	7 3⅞	4.2760	2 0¾	27.2480	.1583
5	7 7	4.5869	2 1⅝	28.5855	.1698
6	7 10¼	4.9087	2 2½	30.5910	.1818
7	8 1⅜	5.2413	2 3⅜	32.6637	.1941
8	8 4½	5.5850	2 4¼	34.8057	.2068
9	8 7⅝	5.9395	2 5¼	37.0149	.2199
10	8 10¾	6.3049	2 6⅛	39.2921	.2335
11	9 1⅞	6.6813	2 7	41.6378	.2474
3 *ft.*	9 5	7.0686	2 7⅞	44.0515	.2618
1	9 8¼	7.4666	2 8¾	46.5318	.2765
2	9 11⅝	7.8757	2 9⅝	49.0813	.2916
3	10 2½	8.2957	2 10¼	51.6988	.3072
4	10 5⅝	8.7265	2 11⅜	54.3835	.3232
5	10 8¾	9.1683	3 0¼	57.0994	.3395
6	10 11⅞	9.6211	3 1⅛	60.9587	.3565
7	11 3	10.0846	3 2	62.8472	.3733
8	11 6⅛	10.5591	3 3	65.8043	.3911
9	11 9⅜	11.0446	3 3⅞	68.8299	.4090
10	12 5½	11.5409	3 4¾	71.9228	.4274
11	12 3⅝	12.0481	3 5⅝	75.0837	.4462
4 *ft.*	12 6¾	12.5664	3 6½	78.3128	.4654
1	12 9⅞	13.0952	3 7⅜	81.6092	.4851
2	13 1	13.6353	3 8¼	84.9751	.5050
3	13 4⅛	14.1862	3 9⅛	85.8583	.5254
4	13 7¼	14.7479	3 10	91.9089	.5462
5	13 10½	15.3206	3 10⅞	95.4779	.5674
6	14 1⅝	15.9043	3 11⅞	99.1155	.5893
7	14 4⅝	16.4986	4 0¾	102.8192	.6111
8	14 7⅞	17.1041	4 1⅝	106.5927	.6334
9	14 11	17.7205	4 2½	110.4341	.6563
10	15 2⅛	18.3476	4 3⅜	114.3421	.6795
11	15 5¼	18.9858	4 4¼	118.3218	.7032

in & es.	Circum. in feet and inches.	Area in feet.	Side of — square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
?.	15 8½	19.6350	4 5⅝	122.3653	.7272
1	15 11¾	20.2947	4 6	126.4765	.7516
2	16 2¾	20.9656	4 6⅜	130.6576	.7764
3	16 5¾	21.6475	4 7⅛	134.9072	.8017
4	16 9	22.3400	4 8⅛	139.2228	.8275
5	17 0⅛	23.0437	4 9⅛	143.6083	.8534
6	17 3⅛	23.7583	4 10½	148.0617	.8800
7	17 6⅜	24.4835	4 11⅜	152.5811	.9071
8	17 9⅜	25.2199	5 0⅜	157.1704	.9340
9	18 0⅜	25.9672	5 1⅜	161.8275	.9617
10	18 3⅞	26.7251	5 2	166.5506	.9897
11	18 7⅛	27.4943	5 2⅞	171.3444	1.0184
6 *ft.*	18 10⅛	28.2744	5 3⅞	176.2069	1.0472
1	19 1¼	29.0649	5 4⅝	181.1324	1.0764
2	19 4⅜	29.8668	5 5½	185.1298	1.1042
3	19 7½	30.6796	5 6⅜	191.1952	1.1363
4	19 10⅝	31.5029	5 7⅜	196.3329	1.1667
5	20 1⅞	32.3376	5 8¼	201.5279	1.1976
6	20 4⅞	33.1831	5 9⅛	206.7970	1.2290
7	20 8⅛	34.0391	5 10	212.1376	1.2607
8	20 11½	34.9065	5 10⅞	217.5373	1.2928
9	21 2⅜	35.7847	5 11¾	223.0102	1.3253
10	21 5½	36.6735	6 0⅝	228.4492	1.3582
11	21 8¾	37.5736	6 1½	234.1586	1.3926
7 *ft.*	21 11⅞	38.4846	6 2⅜	239.8360	1.4254
1	22 3	39.4060	6 3¼	245.5781	1.4602
2	22 6⅛	40.3388	6 4⅛	251.3914	1.4940
3	22 9¼	41.2825	6 5⅛	257.2725	1.5300
4	23 0⅜	42.2367	6 6	263.2191	1.5643
5	23 2⅛	43.2022	6 6⅞	269.2361	1.6001
6	23 6¾	44.1787	6 7¾	275.3216	1.6361
7	23 11	45.1656	6 8⅝	281.4720	1.6728
8	24 1⅛	46.1638	6 9½	287.6928	1.7098
9	24 4⅛	47.1730	6 10⅜	293.9721	1.7471
10	24 7¼	48.1926	6 11¼	300.3362	1.7849
11	24 10⅜	49.2236	7 0	306.7614	1.8231
8 *ft.*	25 1½	50.2656	7 0⅛	313.2552	1.8617
1	25 4⅝	51.3178	7 1¾	319.8125	1.9007
2	25 7⅞	52.3816	7 2⅞	326.4421	1.9394
3	25 11	53.4562	7 3¾	333.1390	1.9800
4	26 2⅛	54.5412	7 4⅝	339.9007	2.0201
5	26 5¼	55.6377	7 5½	346.7341	2.0607
6	26 8⅜	56.7451	7 6⅜	353.6354	2.1017
7	26 11½	57.8628	7 7¼	360.6009	2.1430
8	27 2¾	58.9920	7 8⅛	367.6381	2.1850
9	27 5¾	60.1321	7 9⅛	374.3432	2.2268
10	27 9	61.2826	7 9⅞	381.9031	2.3120
11	28 0⅛	62.4445	7 10¾	389.1541	2.4001

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
9 *ft.*	28 3¼	63.6174	7 11⅝	396.4636	2.3562
1	28 6⅝	64.3006	8 0½	403.8373	2.4000
2	28 9½	65.9951	8 1½	411.2814	2.4443
3	29 0⅝	67.2007	8 2⅜	418.7947	2.4889
4	29 3¾	68.4166	8 3¼	426.3722	2.5339
5	29 7	69.6440	8 4⅛	434.0214	2.5795
6	29 10⅛	70.8823	8 5	441.7384	2.6263
7	30 1¾	72.1309	8 5⅞	449.5197	2.6715
8	30 4⅜	73.3910	8 6¾	457.3727	2.7183
9	30 7½	74.6620	8 7⅝	465.2935	2.7653
10	30 11⅛	75.9433	8 8½	473.2786	2.8128
11	31 1¾	77.2362	8 9½	481.3359	2.8607
10 *ft.*	31 5	78.5400	8 10¼	489.4612	2.9089
1	31 8⅛	79.8540	8 11¼	497.6501	2.9575
2	31 11¼	81.1795	9 0⅛	505.9106	3.0066
3	32 2⅜	82.5160	9 1	514.2397	3.0561
4	32 5½	83.8627	9 1⅞	522.6323	3.1060
5	32 8⅝	85.2211	9 2¾	530.9978	3.1563
6	32 11¾	86.5903	9 3⅝	539.6307	3.2070
7	33 2⅞	87.9697	9 4½	548.2271	3.2211
8	33 6⅛	89.3608	9 5⅜	556.8965	3.3096
9	33 9¼	90.7627	9 6¼	565.2331	3.3615
10	34 0⅜	92.1749	9 7¼	574.4339	3.4138
11	34 3½	93.5986	9 8⅛	583.3064	3.4665
11 *ft.*	34 6¾	95.0334	9 8⅞	592.2481	3.5197
1	34 9⅞	96.4783	9 9⅞	601.2529	3.5733
2	35 0⅞	97.9347	9 10¾	610.3290	3.6272
3	35 4⅛	99.4021	9 11⅝	619.4738	3.6815
4	35 7¼	100.8797	10 0½	628.6822	3.7362
5	35 10⅝	102.3689	10 1⅜	637.9629	3.7914
6	36 1½	103.8691	10 2¼	647.3122	3.8470
7	36 4½	105.3794	10 3⅛	656.7244	3.9029
8	36 7¾	106.9013	10 4	666.2089	3.9593
9	36 10⅞	108.4342	10 5	675.7619	4.0160
10	37 2¼	109.9772	10 5⅞	685.3779	4.0732
11	37 5¼	111.5319	10 6¾	695.0668	4.1308
12 *ft.*	37 8⅜	113.0976	10 7⅝	706.8242	4.1888
1	37 11½	114.6732	10 8½	714.6433	4.2471
2	38 2¾	116.2607	10 9⅜	724.5366	4.3059
3	38 5¾	117.8590	10 10¼	734.4972	4.3651
4	38 8⅞	119.4674	10 11⅛	744.5208	4.4241
5	39 0	121.0876	11 0	754.6179	4.4847
6	39 3¼	122.7187	11 0⅞	764.7829	4.5451
7	39 6⅜	124.3598	11 1⅞	775.0102	4.6059
8	39 9½	126.0127	11 2⅝	785.3111	4.6671
9	40 0⅝	127.6765	11 3⅝	795.6799	4.7287
10	40 3¾	129.3504	11 4½	806.1116	4.7907
11	40 6⅞	131.0360	11 5⅜	816.6163	4.8531

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
13 *ft.*	40 10	132.7326	11 6¼	827.1895	4.9160
1	41 1⅛	134.4391	11 7⅛	837.8244	4.9792
2	41 4⅜	136.1574	11 8⅛	848.5329	5.0428
3	41 7½	137.8867	11 8⅞	859.3099	5.1106
4	41 10⅝	139.6260	11 9¾	870.1492	5.1713
5	42 1⅝	141.3771	11 10⅝	881.0620	5.2361
6	42 4⅞	143.1391	11 11⅝	892.0428	5.3014
7	42 8	144.9111	12 0½	907.0859	5.3670
8	42 11⅛	146.6949	12 1⅜	914.2026	5.4331
9	43 2¼	148.4896	12 2¼	923.3871	5.4996
10	43 5½	150.2943	12 3⅛	936.6340	5.5653
11	43 8⅝	152.1109	12 4	947.9551	5.6337
14 *ft.*	43 11¾	153.9384	12 4⅞	959.3441	5.7014
1	44 2⅞	155.7758	12 5⅝	970.7947	5.7694
2	44 6	157.6250	12 6½	982.3190	5.8369
3	44 9⅛	159.4852	12 7½	993.9117	5.9069
4	45 0¼	161.3553	12 8⅜	1005.5662	5.9761
5	45 3½	163.2373	12 9⅜	1017.2958	6.0458
6	45 6⅝	165.1303	12 10¼	1029.0920	6.1159
7	45 9¾	167.0331	12 11⅛	1040.9502	6.1864
8	46 0⅞	168.9479	13 0	1052.8733	6.2573
9	46 4	170.8735	13 1⅛	1064.8846	6.3286
10	46 7⅛	172.8091	13 1¾	1076.9462	6.4410
11	46 11¼	174.7565	13 2⅝	1089.0825	6.4724
15 *ft.*	47 1½	176.7150	13 3½	1101.2878	6.5450
1	47 4⅝	178.6832	13 4⅜	1113.4537	6.6178
2	47 7¾	180.6634	13 5¼	1125.8943	6.6912
3	47 10⅞	182.6545	13 6⅛	1138.3028	6.7649
4	48 2½	184.6555	13 7⅛	1149.7730	6.8390
5	48 5⅛	186.6684	13 8	1163.3174	6.9126
6	48 8¼	188.6923	13 8⅞	1172.9304	6.9886
7	48 11⅜	190.7260	13 9¾	1188.6054	7.0639
8	49 2⅝	192.7716	13 10⅝	1201.3626	7.1396
9	49 5¾	194.8282	13 11½	1214.1693	7.2158
10	49 8⅞	196.8946	14 0⅜	1227.0471	7.2923
11	50 0	198.9730	14 1¼	1236.9997	7.3693
16 *ft.*	50 3⅛	201.0624	14 2⅛	1253.0208	7.4467
1	50 6¼	203.1615	14 3	1266.1023	7.5245
2	50 9⅜	205.2726	14 3⅞	1279.2588	7.6026
3	51 0½	207.3946	14 4⅞	1292.4831	7.6812
4	51 3¾	209.5264	14 5¾	1306.7685	7.7602
5	51 6½	211.6703	14 6⅝	1319.1293	7.8396
6	51 10	213.8251	14 7½	1332.5580	7.9194
7	52 1⅛	215.9896	14 8⅜	1346.0471	7.9996
8	52 4¼	218.1662	14 9¼	1359.6138	8.0802
9	52 7⅜	220.3537	14 10⅛	1373.2442	8.1612
10	52 10½	222.5510	14 11	1386.9378	8.2426
11	53 1⅝	224.7603	14 11⅞	1400.7061	8.3444

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
17 *ft.*	53 4⅞	226.9806	15 0¾	1414.5430	8.4067
1	53 8	229.2105	15 1⅝	1428.4398	8.4890
2	53 11⅛	231.4525	15 2⅝	1442.4119	8.5352
3	54 2⅛	233.7055	15 3½	1456.4526	8.6557
4	54 5⅜	235.9682	15 4⅜	1470.5538	8.7395
5	54 8½	238.2430	15 5¼	1484.6303	8.8238
6	54 11⅝	240.5287	15 6⅛	1498.9748	8.9081
7	55 2⅞	242.8241	15 7	1513.2792	8.9234
8	55 6	245.1316	15 7⅞	1527.6601	9.0789
9	55 9⅛	247.4500	15 8¾	1542.1084	9.1648
10	56 0¼	249.7781	15 9⅝	1566.6171	9.2510
11	56 3½	252.1184	15 10½	1571.2018	9.3377
18 *ft.*	56 6½	254.4696	15 11⅜	1585.8545	9.4248
1	56 9⅝	256.8303	16 0¾	1600.5664	9.5122
2	57 0⅞	259.2033	16 1¼	1615.3549	9.6000
3	57 4	261.5872	16 2⅛	1630.2114	9.6884
4	57 7⅛	263.9807	16 3⅛	1645.1277	9.7252
5	57 10¼	266.3864	16 3⅞	1660.1200	9.8661
6	58 1⅜	268.8031	16 4¾	1675.1809	9.9556
7	58 4½	271.2293	16 5⅝	1690.3009	10.0451
8	58 7⅝	273.6678	16 6½	1705.4977	10.1358
9	58 10¾	276.1171	16 7⅜	1720.7617	10.2264
10	59 2	278.5761	16 8¼	1736.0862	10.3176
11	59 5⅛	281.0472	16 9¼	1751.4861	10.4091
19 *ft.*	59 8¼	283.5294	16 10	1766.9552	10.5011
1	59 11⅓	286.0210	16 11	1782.4828	10.5933
2	60 2½	288.5249	16 11⅞	1798.0871	10.6861
3	60 5⅝	291.0397	17 0¾	1813.7594	10.7792
4	60 8¾	293.5641	17 1⅝	1829.4914	10.8727
5	60 11⅞	296.1107	17 2½	1845.3005	10.9665
6	61 3⅛	298.6483	17 3⅜	1861.0762	11.0610
7	61 6¼	301.2054	17 4¼	1877.1120	11.1663
8	61 9½	303.7747	17 5⅛	1893.1239	11.2509
9	62 0½	306.3550	17 6	1909.2043	11.3464
10	62 3⅝	308.9448	17 7	1925.3439	11.4424
11	62 6¾	311.5469	17 7⅞	1941.5602	11.5384
20 *ft.*	62 9⅞	314.1600	17 8⅝	1957.8451	11.6355
1	63 1⅛	316.7824	17 9⅝	1974.1879	11.7326
2	63 4¼	319.4173	17 10½	1990.6086	11.8302
3	63 7⅜	322.0630	17 11⅜	2007.0966	11.9282
4	63 11½	324.7182	18 0¼	2023.6438	12.0266
5	64 1⅝	327.3858	18 1⅛	2040.2683	12.1254
6	64 4¾	330.0643	18 2	2056.9607	12.2246
7	64 7⅞	332.7522	18 2⅞	2073.7117	12.3241
8	64 11	335.4525	18 3¾	2090.5399	12.4241
9	65 2¼	338.1637	18 4¾	2107.4361	12.5245
10	65 5⅜	340.8844	18 5⅝	2124.3915	12.6253
11	65 8¼	343.6174	18 6½	2141.4236	12.7265

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
21 *ft.*	65 11⅛	346.3614	18 7¼	2158.5242	12.8282
1	66 2¾	349.1147	18 8¼	2175.6828	12.9301
2	66 5⅞	351.8804	18 9⅛	2192.9186	13.0326
3	66 9	354.6571	18 10	2210.2110	13.1354
4	66 0⅛	357.4432	18 10⅞	2227.5860	13.2386
5	67 3⅜	360.2417	18 11¾	2245.0362	13.3422
6	67 6½	363.0511	19 0⅝	2262.5344	13.4463
7	67 9⅝	365.8698	19 1⅝	2280.1004	13.5507
8	68 0¾	368.7011	19 2½	2297.7452	13.6555
9	68 3⅞	371.5432	19 3⅜	2315.4572	13.7608
10	68 7	374.3947	19 4¼	2333.2277	13.8664
11	68 10¼	377.2587	19 5⅛	2351.0762	13.9725
22 *ft.*	69 1⅜	380.1336	19 5⅞	2368.9925	14.0800
1	69 4½	383.0177	19 6⅞	2386.9663	14.1858
2	69 7⅝	385.9144	19 7¾	2405.0185	14.2931
3	69 10¾	388.8220	19 8⅝	2423.1387	14.4008
4	70 1⅞	391.7389	19 9½	2441.3168	14.5088
5	70 5	394.6683	19 10⅜	2458.5728	14.6173
6	70 8¼	397.6087	19 11⅜	2477.9074	14.7262
7	70 11⅛	400.5583	20 0¼	2496.2793	14.8354
8	71 2½	403.5204	20 1⅛	2514.7391	14.9452
9	71 5⅝	406.4935	20 2	2533.2674	15.0558
10	71 8¾	409.4759	20 2⅞	2551.8538	15.1657
11	71 11⅞	412.4707	20 3¾	2570.5174	15.2766
23 *ft.*	72 3	415.4766	20 4½	2589.2501	15.3880
1	72 6⅛	418.4915	20 5½	2607.9390	15.4996
2	72 9⅜	421.5192	20 6⅜	2626.9076	15.6118
3	73 0½	424.5577	20 7¼	2645.8435	15.7243
4	73 3⅝	427.6055	20 8⅛	2664.8374	15.8372
5	73 6¾	430.6658	20 9⅛	2683.9092	15.9505
6	73 9⅞	433.7371	20 10	2703.0496	16.0643
7	74 1	436.8175	20 10⅞	2722.2465	16.1784
8	74 4⅛	439.9106	20 11¾	2741.5228	16.2929
9	74 7¼	443.0146	21 0⅝	2760.8669	16.4079
10	74 10⅝	446.1278	21 1½	2780.2684	16.5232
11	75 1⅝	449.2536	21 2⅜	2799.7484	16.6390
24 *ft.*	75 4¾	452.3904	21 3¼	2819.2969	16.7556
1	75 7⅞	455.5362	21 4⅛	2838.9015	16.8717
2	75 11	458.6948	21 5	2858.5859	16.9886
3	76 2⅛	461.8642	21 6	2878.3376	17.1060
4	76 5¼	465.0428	21 6⅞	2898.1467	17.2608
5	76 8½	468.2341	21 7¾	2918.0349	17.3420
6	76 11⅝	471.4363	21 8⅝	2937.9941	17.4606
7	77 2¾	474.6476	21 9½	2958.0038	17.5795
8	77 5⅞	477.8716	21 10⅜	2978.0958	17.6989
9	*77 9*	481.1065	21 11¼	2998.2557	17.8187
10	*78 0⅛*	484.3506	22 0⅛	3018.4729	17.9389
11	*78 3¼*	487.6073	22 1	3038.3686	18.0579

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
25 *ft.*	78 6⅜	490.8750	22 1⅞	3059.1330	18.1805
1	78 9½	494.1516	22 2¾	3079.5527	18.2385
2	79 0⅝	497.4411	22 3¾	3100.0529	18.4237
3	79 3⅞	500.7415	22 4⅝	3120.6210	18.6687
4	79 7⅛	504.0510	22 6½	3141.2458	18.7196
5	79 11⅛	507.3732	22 6⅝	3161.9497	18.7916
6	80 1¼	510.7063	22 7¼	3182.7214	18.9150
7	80 4⅝	514.0484	22 8⅛	3203.5496	19.0388
8	80 7⅝	517.4034	22 9	3224.4579	19.1630
9	80 10¾	520.7692	22 9⅞	3245.4336	19.2877
10	81 1⅞	524.1441	22 10¾	3266.4860	19.4127
11	81 5	527.5318	22 11⅝	3287.6381	19.5382
26 *ft.*	81 8⅛	530.9304	23 0½	3308.7582	19.6640
1	81 11¼	534.3379	23 1½	3329.9937	19.7902
2	82 2⅜	537.7583	23 2⅜	3351.3097	19.9169
3	82 5¼	541.1896	23 3¼	3372.6935	20.0440
4	82 8⅝	544.6299	23 4⅛	3394.1535	20.1714
5	82 11⅞	548.0830	23 5	3415.6532	20.2993
6	83 3	551.5471	23 5⅞	3437.2415	20.4276
7	83 6⅛	555.0201	23 6¾	3458.8852	20.5562
8	83 9¼	558.5059	23 7⅝	3480.6087	20.6854
9	84 0⅜	562.0027	23 8½	3502.3008	20.8149
10	84 3½	565.5084	23 9⅜	3524.2483	20.9447
11	84 6⅝	569.0270	23 10¼	3546.1762	21.0750
27 *ft.*	84 9⅞	572.5566	23 11⅛	3568.1727	21.2058
1	85 1	576.0949	24 0⅛	3590.2234	21.3368
2	85 4¼	579.6463	24 1	3612.3557	21.4683
3	85 8⅛	583.2085	24 1⅞	3634.5553	21.6003
4	85 11⅜	586.7796	24 2¾	3656.8104	21.7325
5	86 1½	590.3637	24 3⅝	3679.1465	21.8653
6	86 4⅝	593.9587	24 4½	3701.5506	21.9984
7	86 7⅞	597.5625	24 5⅜	3724.0094	22.1319
8	86 11	601.1793	24 6¼	3746.5493	22.2569
9	87 2⅛	604.8070	24 7⅛	3769.1572	22.4002
10	87 5¼	608.4436	24 8⅛	3791.8205	22.5349
11	87 8⅜	612.0931	24 9	3814.5641	22.6701
28 *ft.*	87 11½	615.7536	24 9¾	3837.3764	22.8056
1	88 2⅝	619.4228	24 10¾	3860.2428	22.9415
2	88 5¾	623.1050	24 11½	3883.1903	23.0779
3	88 9	626.7982	25 0½	3905.4063	23.2147
4	89 0⅛	630.5002	25 1⅜	3929.2772	23.3154
5	89 3¼	634.2152	25 2¼	3952.4291	23.4894
6	89 6⅜	637.9411	25 3⅛	3975.6489	23.6274
7	89 9½	641.6758	25 4	3998.9235	23.7457
8	90 0⅝	645.4235	25 4⅞	4022.2682	23.9045
9	90 3¾	649.1821	25 5⅞	4045.7028	24.0437
10	90 6⅞	652.9495	25 6¾	4069.1813	24.1832
11	90 11⅛	656.7300	25 7⅛	4092.3413	24.3249

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
29 *ft.*	91 1¼	660.5214	25 8⅜	4116.3693	24.4637
1	91 4⅜	664.3214	25 9⅜	4140.0509	24.6044
2	91 7½	668.1346	25 10¼	4163.8148	24.7457
3	91 10⅝	671.9587	25 11⅛	4187.6466	24.8873
4	92 1¾	675.7915	26 0	4211.5326	25.0293
5	92 4⅞	679.6375	26 0⅞	4234.4839	25.1717
6	92 8⅛	683.4943	26 1¾	4259.5364	25.2405
7	92 11⅜	687.3598	26 2⅝	4283.6263	25.4577
8	93 2⅝	691.2385	26 3⅝	4308.7983	25.6014
9	93 5½	695.1280	26 4½	4332.0376	25.7454
10	93 8⅝	699.0263	26 5⅝	4356.3319	25.8898
11	93 11⅞	702.9377	26 6¼	4380.7077	26.0347
30 *ft.*	94 2⅞	706.8600	26 7	4405.1515	26.1800
1	94 6	710.7909	26 8	4429.6488	26.3255
2	94 9¼	714.7350	26 8⅞	4454.2285	26.4716
3	95 0⅜	718.6900	26 9¾	4478.8760	26.6181
4	95 3½	722.6537	26 10⅝	4503.5779	26.7649
5	95 6⅝	726.6305	26 11½	4528.3612	26.9122
6	95 9¾	730.6183	27 0⅜	4553.2132	27.0599
7	96 0⅞	734.6147	27 1⅜	4578.1188	27.2079
8	96 4	738.6242	27 2¼	4603.1060	27.3934
9	96 7¼	742.6447	27 3⅛	4628.1617	27.5153
10	96 10⅜	746.6738	27 4	4653.2711	27.6545
11	97 1½	750.7161	27 4⅞	4678.4627	27.8043
31 *ft.*	97 4⅝	754.7694	27 5⅝	4703.7229	27.9544
1	97 7¾	758.8311	27 6⅝	4729.0354	28.1048
2	97 10⅞	762.9062	27 7½	4754.4314	28.2557
3	98 2	766.9921	27 8⅜	4779.8947	28.4070
4	98 5⅛	771.0866	27 9¼	4805.4116	28.5587
5	98 8⅜	775.1944	27 10⅛	4831.0115	28.7109
6	98 11½	779.3131	27 11⅛	4856.6792	28.8634
7	99 2⅝	783.4403	28 0	4882.3999	29.0163
8	99 5¾	787.5808	28 0⅞	4908.2035	29.1696
9	99 8⅞	791.7322	28 1¾	4934.0750	29.3234
10	100 0	795.8922	28 2⅝	4960.0001	29.4774
11	100 3⅛	800.0654	28 3½	4986.0075	29.6320
32 *ft.*	100 6⅜	804.2496	28 4¼	5012.0835	29.7870
1	100 9½	808.4422	28 5¼	5038.2117	29.9423
2	101 0⅝	812.6481	28 6⅛	5064.4229	30.0980
3	101 3¾	816.8650	28 7	5090.7026	30.2543
4	101 6⅞	821.0904	28 8	5117.0353	30.4107
5	101 10	825.3291	28 8⅞	5143.4509	30.5677
6	102 1⅛	829.5787	28 9¾	5169.9344	30.7251
7	102 4⅜	833.8368	28 10⅝	5196.4709	30.8828
8	102 7½	838.1082	28 11½	5223.0903	31.0410
9	*102 10⅝*	842.3905	29 0⅜	5249.7775	31.1996
10	*103 1¾*	846.6813	29 1¼	5277.0178	31.3585
11	*103 4⅞*	850.9855	29 2⅛	5303.3416	31.5178

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
33 *ft.*	103 8	855.3006	29 2⅜	5330.2333	31.6778
1	103 11⅛	859.6240	29 3⅜	5317.1767	31.8379
2	104 2¼	863.9609	29 4¾	5384.2043	31.9943
3	104 5⅜	868.3087	29 5¾	5411.2998	32.1595
4	104 8⅝	872.6649	29 6⅝	5438.4476	32.3579
5	104 11¾	877.0346	29 7½	5465.6796	32.4827
6	105 2⅞	881.4151	29 8⅜	5492.9789	32.6450
7	105 6	885.8040	29 9¼	5520.3305	32.8075
8	105 9⅛	890.2064	29 10⅛	5547.7662	32.9706
9	106 0¼	894.6196	29 11	5575.2693	33.1340
10	106 3⅜	899.0413	29 11⅞	5602.8253	33.2978
11	106 6⅝	903.4763	30 0¾	5630.4643	33.4613
34 *ft.*	106 9¾	907.9224	30 1½	5658.1723	33.6267
1	107 0⅞	912.3767	30 2½	5685.9315	33.7917
2	107 4	916.8445	30 3½	5713.7749	33.9572
3	107 7⅛	921.3232	30 4⅜	5741.6861	34.1231
4	107 10¼	925.8103	30 5¼	5769.6497	34.2892
5	108 1⅜	930.3103	30 6⅛	5797.6969	34.4559
6	108 4⅝	934.8223	30 7	5825.8115	34.6230
7	108 7¾	939.3421	30 7⅞	5853.9699	34.7904
8	108 10⅞	943.8753	30 8¾	5882.2308	34.9583
9	109 2	948.4195	30 9⅝	5910.5503	35.1266
10	109 5⅛	952.9720	30 10½	5938.9215	35.2952
11	109 8¼	957.5380	30 11⅜	5967.3768	35.4643
35 *ft.*	109 11⅜	962.1150	31 0¼	5989.9006	35.6339
1	110 2⅝	966.7001	31 1¼	6024.4750	35.8037
2	110 5¾	971.2989	31 2⅛	6053.1347	35.9740
3	110 8⅞	975.9085	31 3	6081.8617	36.1447
4	111 0	980.5264	31 3⅞	6110.6405	36.3158
5	111 3⅛	985.1579	31 4¾	6139.5040	36.4873
6	111 6¼	989.8003	31 5⅝	6168.4354	36.6592
7	111 9⅜	994.4509	31 6½	6197.4180	36.8315
8	112 0½	999.1151	31 7⅜	6226.4833	37.0042
9	112 3¾	1003.7902	31 8¼	6256.6205	37.1404
10	112 6⅞	1008.4736	31 9⅛	6284.8074	37.3509
11	112 10	1013.1705	31 10⅛	6314.0785	37.5248
36 *ft.*	113 1⅛	1017.8784	31 10⅞	6343.4181	37.6992
1	113 4¼	1022.5944	31 11⅞	6372.8083	37.8738
2	113 7⅜	1027.3240	32 0¾	6403.2831	38.0490
3	113 10¼	1032.0646	32 1⅝	6431.8265	38.2246
4	114 1¾	1036.8134	32 2½	6461.4211	38.4005
5	114 4⅞	1041.5758	32 3⅜	6491.1003	38.5761
6	114 8	1046.3491	32 4¼	6520.8475	38.7537
7	114 11⅛	1051.1306	32 5⅛	6550.6458	38.9307
8	115 2¼	1055.9257	32 6	6580.5289	39.1083
9	115 5⅜	1060.7317	32 6⅞	6610.4799	39.2863
10	115 9¼	1065.5459	32 7⅞	6640.4820	39.4646
11	115 11⅝	1070.3738	32 8¾	6670.5695	39.6435

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
37 *ft.*	116 2⅞	1075.2126	32 9½	6700.7249	39.8227
1	116 6	1080.0594	32 10½	6730.9301	40.0220
2	116 9⅛	1084.9201	32 11⅜	6762.2220	40.1822
3	117 0¼	1089.7915	33 0¼	6791.5806	40.3626
4	117 3½	1094.6711	33 1⅛	6821.9902	40.5434
5	117 6½	1099.5644	33 2	6852.4853	40.7246
6	117 9⅝	1104.4687	33 2⅞	6883.0489	40.9062
7	118 0¾	1109.3810	33 3¾	6913.6623	41.0882
8	118 4	1114.3071	33 4⅝	6944.3618	41.2706
9	118 7⅛	1119.2440	33 5⅝	6975.1286	41.4535
10	118 10¼	1124.1891	33 6½	7005.9464	41.6366
11	119 1⅜	1129.1478	33 7⅜	7036.8490	41.8203
38 *ft.*	119 4½	1134.1176	33 8⅛	7067.8208	42.0043
1	119 7⅝	1139.0953	33 9⅛	7098.8419	42.1887
2	119 10¾	1144.0868	33 10	7129.9489	42.3736
3	120 2	1149.0892	33 10⅞	7161.1238	42.5588
4	120 5⅛	1154.0997	33 11¾	7192.3493	42.7444
5	120 8⅜	1159.1239	34 0⅝	7223.6601	42.9305
6	120 11⅜	1164.1591	34 1½	7255.0395	43.1459
7	121 2½	1169.2023	34 2⅜	7286.4687	43.3034
8	121 5⅝	1174.2592	34 3⅜	7317.9833	43.4911
9	121 8¾	1179.3271	34 4¼	7349.5664	43.6417
10	121 11⅞	1184.4030	34 5⅛	7381.1994	43.8668
11	122 3⅛	1189.4927	34 6	7412.9185	44.0553
39 *ft.*	122 6¼	1194.5934	34 6¾	7444.7054	44.2442
1	122 9½	1199.7195	34 7¾	7476.6519	44.4340
2	123 0½	1204.8244	34 8⅝	7478.4626	44.6231
3	123 3⅝	1209.9577	34 9½	7540.4563	44.8123
4	123 6¾	1215.0990	34 10⅜	7572.4969	45.0036
5	123 9⅞	1220.2542	34 11¼	7604.6239	45.1946
6	124 1⅛	1225.4203	35 0⅛	7636.8193	45.3859
7	124 4¼	1230.5943	35 1⅛	7669.0636	45.5775
8	124 7⅜	1235.7822	35 2	7701.3946	45.7697
9	124 10½	1240.9810	35 2⅞	7733.7935	45.9622
10	125 1⅝	1246.1878	35 3¾	7766.2423	46.1551
11	125 4¾	1251.4084	35 4⅝	7798.7771	46.3484
40 *ft.*	125 7⅞	1256.6400	35 5⅝	7831.3804	46.5422
1	125 11	1261.8794	35 6⅝	7864.0324	46.7362
2	126 2¼	1267.1327	35 7¼	7896.7709	46.9308
3	126 5⅜	1272.3970	35 8⅛	7929.5781	47.1257
4	126 8½	1277.6692	35 9	7962.4344	47.3211
5	126 11⅝	1282.9553	35 10	7995.3774	47.5168
6	127 2¾	1288.2523	35 10⅞	8028.2883	47.7130
7	127 5⅞	1293.5572	35 11¾	8061.4484	47.9095
8	127 9	1298.8760	36 0⅝	8094.5952	48.1065
9	128 0¼	1304.2057	36 1½	8127.8099	48.3039
10	128 3⅜	1309.5433	36 2⅜	8161.0738	48.5016
11	128 6½	1314.8949	36 3¼	8194.4250	48.6998

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
41 *ft.*	128 9⅝	1320.2574	36 4½	8227.8441	48.8984
1	129 0¾	1325.6276	36 5	8261.3112	49.0973
2	129 3⅞	1331.0119	36 5⅞	8294.8661	49.2967
3	129 7	1336.4071	36 6¾	8328.4890	49.4965
4	129 10⅛	1341.8101	36 7¾	8362.1605	49.6967
5	130 1⅜	1347.2271	36 8⅝	8395.9192	49.8973
6	130 4½	1352.6551	36 9½	8429.7465	50.0983
7	130 7⅝	1358.0908	36 10⅜	8463.6218	50.2997
8	130 10¾	1363.5406	36 11¼	8497.5850	50.5015
9	131 1⅞	1369.0012	37 0⅛	8531.6154	50.7037
10	131 5	1374.4697	37 1	8565.6951	50.9063
11	131 8⅛	1379.9521	37 1⅞	8599.8614	51.1093
42 *ft.*	131 11⅜	1385.4456	37 2⅝	8634.0969	51.3128
1	132 2½	1390.2467	37 3⅝	8664.0174	51.4906
2	132 5⅝	1396.4619	37 4½	8702.7505	51.7208
3	132 8¾	1401.9880	37 5½	8737.1892	51.9257
4	132 11⅞	1407.5219	37 6¾	8771.6764	52.1304
5	133 3	1413.0698	37 7¾	8806.2509	52.3355
6	133 6⅛	1418.6287	37 8⅝	8840.8940	52.5418
7	133 9¼	1424.1952	37 9	8875.5844	52.7479
8	134 0½	1429.7759	37 9⅞	8910.3634	52.9546
9	134 3⅝	1435.3675	37 10¾	8945.2102	53.1618
10	134 6¾	1440.9668	37 11⅝	8980.1050	53.3691
11	134 9⅞	1446.5802	38 0½	9015.0878	53.5770
43 *ft.*	135 1	1452.2046	38 1¼	9050.1390	53.7853
1	135 4⅛	1457.8365	38 2¼	9085.2370	53.9939
2	135 7¼	1463.4827	38 3¼	9120.3741	54.2030
3	135 10½	1469.1397	38 4⅛	9155.6786	54.4126
4	136 1⅜	1474.8044	38 5	9190.9810	54.6224
5	136 4¾	1480.4833	38 5⅞	9226.3719	54.8323
6	136 7⅞	1486.1731	38 6¾	9261.7307	55.0434
7	136 11	1491.8705	38 7⅝	9297.3369	55.2544
8	137 2⅛	1497.5821	38 8½	9332.9316	55.4363
9	137 5¼	1503.3046	38 9⅜	9368.5942	55.6779
10	137 8⅜	1509.0348	38 10¼	9404.3048	55.8902
11	137 11⅝	1514.7791	38 11⅛	9440.1033	56.1029
44 *ft.*	138 2¾	1520.5344	38 11⅞	9475.9703	56.3161
1	138 5⅞	1526.2971	39 1	9511.8835	56.5295
2	138 9	1532.0742	39 1⅞	9547.8864	56.7435
3	139 0⅛	1537.8622	39 2¾	9583.9572	56.9578
4	139 3¼	1543.6578	39 3⅝	9620.0754	57.1725
5	139 6⅜	1549.4676	39 4½	9656.2820	57.3877
6	139 9⅝	1555.2883	39 5⅜	9692.5566	57.6033
7	140 0¾	1561.1165	39 6¼	9728.8780	57.8191
8	140 3⅞	1566.9591	39 7⅛	9765.2891	58.0355
9	140 7½	1572.8125	39 8	9801.7875	58.2523
10	140 10⅛	1578.6735	39 8⅞	9838.2932	58.4693
11	141 1¼	1584.5488	39 9¾	9874.9081	58.6869

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
45 *ft.*	141 4⅜	1590.4350	39 10½	9911.5909	58.9050
1	141 7½	1596.3286	39 11⅝	9948.3198	59.1233
2	141 10¾	1602.2366	40 0½	9985.1384	59.3421
3	142 1⅞	1608.1555	40 1⅜	10022.025	59.5613
4	142 5	1614.0819	40 2¼	10058.958	59.7808
5	142 8⅛	1620.0226	40 3⅛	10095.980	60.0008
6	142 11¼	1625.9743	40 4	10133.071	60.2212
7	143 2⅜	1631.9334	40 4⅞	10170.208	60.4420
8	143 5½	1637.9068	40 5¾	10207.435	60.6632
9	143 8¾	1643.8912	40 6⅝	10244.729	60.8848
10	143 11⅞	1649.8831	40 7⅝	10277.070	61.1068
11	144 3	1655.8892	40 8½	10319.501	61.3292
46 *ft.*	144 6⅛	1661.9064	40 9⅜	10357.000	61.5521
1	144 9¼	1667.9308	40 10¼	10394.544	61.7752
2	145 0⅜	1673.9698	40 11⅛	10432.179	61.9989
3	145 3½	1680.0196	41 0	10469.880	62.2229
4	145 6⅝	1686.0769	41 0⅞	10507.631	62.4473
5	145 9⅞	1692.1485	41 1¾	10546.469	62.6722
6	146 1⅛	1698.2311	41 2⅝	10583.376	62.8974
7	146 4⅛	1704.3210	41 3½	10621.328	63.1230
8	146 7¼	1710.4254	41 4⅜	10659.371	63.3491
9	146 10⅜	1716.5407	41 5⅜	10697.481	63.5756
10	147 1½	1722.6634	41 6¼	10735.638	63.8021
11	147 4⅝	1728.8005	41 7⅛	10773.884	64.0296
47 *ft.*	147 7¾	1734.9486	41 7¾	10812.199	64.2573
1	147 11	1741.1039	41 8⅞	10850.559	64.4853
2	148 2⅛	1747.2738	41 9¾	10889.010	64.7138
3	148 5¼	1753.4545	41 10⅝	10927.528	64.9427
4	148 8⅜	1759.6426	41 11½	10966.092	65.1719
5	148 11½	1765.8452	42 0⅜	11004.747	65.4017
6	149 2⅝	1772.0587	42 1¼	11043.469	65.6318
7	149 5⅞	1778.2795	42 2⅛	11082.237	65.8622
8	149 8⅞	1784.5148	42 3⅛	11121.096	66.0931
9	150 0⅛	1790.7610	42 4	11160.022	66.3245
10	150 3¼	1797.0145	42 4⅞	11197.994	66.5561
11	150 6⅜	1803.2826	42 5¾	11238.057	66.7882
48 *ft.*	150 9½	1809.5616	42 6½	11287.187	67.0208
1	151 0⅝	1815.8477	42 7½	11316.362	67.2536
2	151 3¾	1822.1485	42 8⅜	11336.629	67.4870
3	151 6⅞	1828.4602	42 9¼	11394.963	67.7209
4	151 10⅛	1834.7791	42 10⅛	11434.343	67.9548
5	152 1¼	1841.1127	42 11	11473.814	68.189
6	152 4⅜	1847.4571	43 0	11513.352	68.42
7	152 7½	1853.8087	43 0⅞	11552.935	68.656
8	152 10⅝	1860.1750	43 1⅞	11592.610	68.8953
9	153 1¾	1866.5521	43 2⅝	11632.352	69.1315
10	153 4⅞	1872.9365	43 3½	11672.140	69.3680
11	153 8⅛	1879.3355	43 4⅜	11712.018	69.6050

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
49 *ft.*	153 11¼	1885.7454	43 5⅛	11750.964	69.8424
1	154 2⅜	1892.1724	43 6⅛	11792.018	70.0804
2	154 5½	1898.5041	43 7	11831.477	70.3150
3	154 8⅝	1905.0367	43 7⅞	11872.188	70.5569
4	154 11⅞	1911.4965	43 8¾	11912.446	70.7961
5	155 2⅜	1917.9609	43 9¾	11952.732	71.0356
6	155 6	1924.4263	43 10⅝	11993.824	71.2750
7	155 9¼	1930.9188	43 11⅛	12033.485	71.5155
8	156 0⅛	1937.3159	44 0⅝	12073.352	71.7524
9	156 3½	1943.9140	44 1¼	12114.472	71.9968
10	156 6⅝	1950.4392	44 2⅛	12155.157	72.2385
11	156 9¾	1956.9691	44 3	12195.831	72.4803
50 *ft.*	157 0⅞	1963.5000	44 3¾	12236.532	72.7222

TABLE

CONTAINING

THE SQUARE & CUBE ROOTS OF ALL NUMBERS

From 1 *to* 1000; *and the*

DIFFERENCE EXISTING BETWEEN EACH ROOT,

BY WHICH

The process for obtaining the roots of numbers, consisting of integers and decimals, is considerably facilitated.

RULE.—Multiply the difference between the root of the integer part of the given number, and the root of the next higher integer number, by the decimal part of the given number, and add the product to the root of the integer number given, the sum is the root required.

EXAMPLE 1.—Required the square root of 53.75.

Difference by table = .0683 × .75 = .051225, and the root of 53 = 7.2801, hence, 7.2801 + .051225 = 7.3313, the root required.

EXAMPLE 2.—Required the cube root of the number 734.26.

Difference by table = .0044 × .90 = .001066, and the root of 734 = 9.0276, hence, 9.0276 + .001066 = 9.0215, the root required.

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
1	1.0000	.4142	1.0000	.2599	45	6.7082	.0741	3.5568	.0262
2	1.4142	.3178	1.2599	.1823	46	6.7823	.0733	3.5830	.0258
3	1.7320	.2680	1.4422	.1452	47	6.8556	.0726	3.6088	.0254
4	2.0000	.2360	1.5874	.1225	48	6.9282	.0718	3.6342	.0251
5	2.2360	.2134	1.7099	.1072	49	7.0000	.0710	3.6593	.0247
6	2.4494	.1963	1.8171	.0950	50	7.0710	.0704	3.6840	.0244
7	2.6457	.1827	1.9129	.0871	51	7.1414	.0697	3.7084	.0241
8	2.8284	.1716	2.0000	.0800	52	7.2111	.0690	3.7325	.0237
9	3.0000	.1622	2.0800	.0744	53	7.2801	.0683	3.7562	.0236
10	3.1622	.1544	2.1544	.0685	54	7.3484	.0677	3.7797	.0232
11	3.3166	.1475	2.2239	.0655	55	7.4161	.0672	3.8029	.0229
12	3.4641	.1414	2.2894	.0619	56	7.4833	.0665	3.8258	.0227
13	3.6055	.1361	2.3513	.0588	57	7.5498	.0659	3.8485	.0223
14	3.7416	.1313	2.4101	.0551	58	7.6157	.0654	3.8708	.0221
15	3.8729	.1271	2.4662	.0536	59	7.6811	.0648	3.8929	.0219
16	4.0000	.1231	2.5198	.0514	60	7.7459	.0643	3.9148	.0216
17	4.1231	.1195	2.5712	.0595	61	7.8102	.0638	3.9364	.0214
18	4.2426	.1162	2.6207	.0477	62	7.8740	.0632	3.9578	.0212
19	4.3588	.1133	2.6684	.0460	63	7.9372	.0628	3.9790	.0210
20	4.4721	.1104	2.7144	.0445	64	8.0000	.0622	4.0000	.0207
21	4.5825	.1079	2.7589	.0431	65	8.0622	.0618	4.0207	.0205
22	4.6904	.1054	2.8020	.0418	66	8.1240	.0613	4.0412	.0203
23	4.7958	.1031	2.8438	.0406	67	8.1853	.0609	4.0615	.0201
24	4.8989	.1011	2.8844	.0396	68	8.2462	.0604	4.0816	.0199
25	5.0000	.0990	2.9240	.0384	69	8.3066	.0600	4.1015	.0197
26	5.0990	.0971	2.9624	.0376	70	8.3666	.0595	4.1212	.0196
27	5.1961	.0954	3.0000	.0365	71	8.4261	.0591	4.1408	.0193
28	5.2915	.0936	3.0365	.0358	72	8.4852	.0588	4.1601	.0192
29	5.3851	.0921	3.0723	.0349	73	8.5440	.0583	4.1793	.0190
30	5.4772	.0905	3.1072	.0341	74	8.6023	.0579	4.1983	.0188
31	5.5677	.0891	3.1413	.0325	75	8.6602	.0565	4.2171	.0187
32	5.6568	.0877	3.1748	.0327	76	8.7177	.0572	4.2358	.0185
33	5.7445	.0864	3.2075	.0321	77	8.7749	.0568	4.2543	.0183
34	5.8309	.0851	3.2396	.0314	78	8.8317	.0564	4.2726	.0182
35	5.9160	.0840	3.2710	.0309	79	8.8881	.0561	4.2908	.0180
36	6.0000	.0827	3.3019	.0303	80	8.9442	.0558	4.3088	.0179
37	6.0827	.0817	3.3322	.0297	81	9.0000	.0553	4.3267	.0177
38	6.1644	.0805	3.3619	.0293	82	9.0553	.0551	4.3444	.0176
39	6.2449	.0796	3.3912	.0287	83	9.1104	.0547	4.3620	.0175
40	6.3245	.0786	3.4199	.0283	84	9.1651	.0544	4.3795	.0173
41	6.4031	.0776	3.4482	.0278	85	9.2195	.0541	4.3968	.0172
42	6.4807	.0767	3.4760	.0273	86	9.2736	.0537	4.4140	.0170
43	6.5574	.0758	3.5033	.0270	87	9.3273	.0535	4.4310	.0169
44	6.6332	.0750	3.5303	.0265	88	9.3808	.0531	4.4479	.0168
45	6.7082		3.5568		89	9.4339		4.4647	

Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
339		4.4647		137	11.7046		5.1551	
368	.0529	4.4814	.0167	138	11.7473	.0427	5.1676	.0125
393	.0525	4.4979	.0165	139	11.7898	.0425	5.1801	.0125
916	.0523	4.5143	.0164	140	11.8321	.0423	5.1924	.0123
436	.0520	4.5306	.0163	141	11.8743	.0422	5.2048	.0124
953	.0517	4.5468	.0162	142	11.9163	.0420	5.2171	.0123
467	.0514	4.5629	.0161	143	11.9582	.0419	5.2293	.0122
979	.0512	4.5788	.0159	144	12.0000	.0418	5.2414	.0121
488	.0589	4.5947	.0159	145	12.0415	.0415	5.2535	.0121
994	.0506	4.6104	.0157	146	12.0830	.0414	5.2656	.0121
498	.0504	4.6260	.0156	147	12.1243	.0413	5.2776	.0120
000	.0502	4.6415	.0155	148	12.1655	.0412	5.2895	.0119
98	.0498	4.6570	.0155	149	12.2065	.0410	5.3014	.0119
95	.0497	4.6723	.0153	150	12.2474	.0409	5.3132	.0118
88	.0493	4.6875	.0153	151	12.2882	.0408	5.3250	.0118
80	.0492	4.7026	.0151	152	12.3288	.0406	5.3368	.0118
69	.0489	4.7176	.0150	153	12.3693	.0405	5.3484	.0116
56	.0487	4.7326	.0150	154	12.4096	.0403	5.3601	.0117
40	.0484	4.7474	.0148	155	12.4498	.0402	5.3716	.0115
23	.0483	4.7622	.0148	156	12.4899	.0401	5.3832	.0116
03	.0480	4.7768	.0146	157	12.5299	.0400	5.3946	.0114
80	.0477	4.7914	.0146	158	12.5698	.0399	5.4061	.0115
56	.0476	4.8058	.0144	159	12.6095	.0397	5.4175	.0114
30	.0474	4.8202	.0144	160	12.6491	.0396	5.4288	.0113
01	.0471	4.8345	.0143	161	12.6885	.0394	5.4401	.0113
70	.0469	4.8488	.0143	162	12.7279	.0394	5.4513	.0112
38	.0468	4.8629	.0141	163	12.7671	.0392	5.4625	.0112
03	.0465	4.8769	.0140	164	12.8062	.0391	5.4737	.0112
66	.0463	4.8909	.0140	165	12.8452	.0390	5.4848	.0111
27	.0461	4.9048	.0139	166	12.8840	.0389	5.4958	.0110
87	.0460	4.9186	.0138	167	12.9228	.0388	5.5068	.0110
44	.0467	4.9324	.0138	168	12.9614	.0387	5.5178	.0110
00	.0456	4.9460	.0136	169	13.0000	.0386	5.5287	.0109
53	.0453	4.9596	.0136	170	13.0384	.0384	5.5396	.0109
05	.0452	4.9731	.0135	171	13.0766	.0382	5.5504	.0108
55	.0450	4.9866	.0135	172	13.1148	.0382	5.5612	.0108
03	.0448	5.0000	.0134	173	13.1529	.0381	5.5720	.0108
49	.0446	5.0132	.0132	174	13.1909	.0380	5.5827	.0107
94	.0445	5.0265	.0133	175	13.2287	.0378	5.5934	.0107
37	.0443	5.0396	.0131	176	13.2664	.0377	5.6040	.0106
78	.0441	5.0527	.0131	177	13.3041	.0376	5.6146	.0106
17	.0439	5.0657	.0130	178	13.3416	.0375	5.6252	.0106
55	.0438	5.0787	.0130	179	13.3790	.0374	5.6357	.0105
91	.0436	5.0916	.0129	180	13.4164	.0373	5.6462	.0105
25	.0434	5.1044	.0128	181	13.4536	.0372	5.6566	.0104
58	.0433	5.1172	.0128	182	13.4907	.0371	5.6670	.0104
89	.0431	5.1299	.0127	183	13.5277	.0370	5.6774	.0104
19	.0430	5.1425	.0126	184	13.5646	.0369	5.6877	.0103
46	.0428	5.1551	.0126	185	13.6014	.0368	5.6980	.0103

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
185	13.6014	.0367	5.6980	.0102	233	15.2643	.0327	6.1534	.0088
186	13.6381	.0366	5.7082	.0102	234	15.2970	.0327	6.1622	.0088
187	13.6747	.0365	5.7184	.0102	235	15.3297	.0327	6.1710	.0087
188	13.7113	.0364	5.7286	.0101	236	15.3622	.0325	6.1797	.0087
189	13.7477	.0363	5.7387	.0101	237	15.3948	.0326	6.1884	.0087
190	13.7840	.0362	5.7488	.0101	238	15.4272	.0324	6.1971	.0087
191	13.8202	.0361	5.7589	.0100	239	15.4596	.0324	6.2058	.0086
192	13.8564	.0360	5.7689	.0100	240	15.4919	.0323	6.2144	.0086
193	13.8924	.0359	5.7789	.0100	241	15.5241	.0322	6.2230	.0086
194	13.9283	.0359	5.7889	.0099	242	15.5563	.0322	6.2316	.0086
195	13.9642	.0357	5.7988	.0099	243	15.5884	.0321	6.2402	.0085
196	14.0000	.0356	5.8087	.0099	244	15.6204	.0320	6.2487	.0085
197	14.0356	.0356	5.8186	.0098	245	15.6524	.0320	6.2573	.0086
198	14.0712	.0355	5.8284	.0098	246	15.6843	.0319	6.2658	.0085
199	14.1067	.0354	5.8382	.0098	247	15.7162	.0319	6.2743	.0084
200	14.1421	.0353	5.8480	.0098	248	15.7480	.0317	6.2827	.0084
201	14.1774	.0352	5.8577	.0097	249	15.7797	.0316	6.2911	.0085
202	14.2126	.0351	5.8674	.0097	250	15.8113	.0316	6.2996	.0083
203	14.2478	.0350	5.8771	.0096	251	15.8429	.0316	6.3079	.0084
204	14.2828	.0350	5.8867	.0096	252	15.8745	.0314	6.3163	.0084
205	14.3178	.0349	5.8963	.0096	253	15.9059	.0314	6.3247	.0083
206	14.3527	.0348	5.9059	.0096	254	15.9373	.0314	6.3330	.0083
207	14.3874	.0347	5.9154	.0095	255	15.9687	.0313	6.3413	.0083
208	14.4222	.0346	5.9249	.0095	256	16.0000	.0312	6.3496	.0082
209	14.4568	.0345	5.9344	.0095	257	16.0312	.0311	6.3578	.0082
210	14.4913	.0345	5.9439	.0094	258	16.0623	.0311	6.3660	.0083
211	14.5258	.0344	5.9533	.0094	259	16.0934	.0311	6.3743	.0082
212	14.5602	.0343	5.9627	.0093	260	16.1245	.0309	6.3825	.0081
213	14.5945	.0343	5.9720	.0094	261	16.1554	.0310	6.3906	.0082
214	14.6287	.0342	5.9814	.0093	262	16.1864	.0308	6.3988	.0081
215	14.6629	.0341	5.9907	.0093	263	16.2172	.0308	6.4069	.0081
216	14.6969	.0340	6.0000	.0093	264	16.2480	.0308	6.4150	.0081
217	14.7309	.0339	6.0092	.0092	265	16.2788	.0307	6.4231	.0081
218	14.7648	.0338	6.0184	.0092	266	16.3095	.0306	6.4312	.0080
219	14.7986	.0337	6.0276	.0092	267	16.3401	.0306	6.4392	.0081
220	14.8323	.0337	6.0368	.0091	268	16.3707	.0305	6.4473	.0080
221	14.8660	.0336	6.0459	.0091	269	16.4012	.0304	6.4553	.0080
222	14.8997	.0335	6.0550	.0091	270	16.4316	.0304	6.4633	.0078
223	14.9332	.0335	6.0641	.0090	271	16.4620	.0304	6.4712	.0080
224	14.9666	.0334	6.0731	.0091	272	16.4924	.0303	6.4792	.0079
225	15.0000	.0333	6.0822	.0090	273	16.5227	.0302	6.4871	.0079
226	15.0332	.0332	6.0911	.0089	274	16.5529	.0302	6.4950	.0079
227	15.0665	.0333	6.1001	.0090	275	16.5831	.0301	6.5029	.0079
228	15.0996	.0331	6.1091	.0090	276	16.6132	.0301	6.5108	.0078
229	15.1327	.0331	6.1180	.0089	277	16.6433	.0300	6.5186	.0079
230	15.1657	.0330	6.1269	.0089	278	16.6733	.0299	6.5265	.0078
231	15.1987	.0329	6.1357	.0088	279	16.7032	.0299	6.5343	.0078
232	15.2315	.0329	6.1445	.0088	280	16.7332	.0298	6.5421	.0078
233	15.2643	.0328	6.1534	.0088	281	16.7629	.0298	6.5499	.0078

Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
630	.0298	6.5499	.0077	329	18.1383	.0276	6.9034	.0070
928	.0298	6.5576	.0078	330	18.1659	.0275	6.9104	.0069
226	.0296	6.5654	.0077	331	18.1934	.0274	6.9173	.0070
522	.0297	6.5731	.0077	332	18.2208	.0274	6.9243	.0070
819	.0296	6.5808	.0077	333	18.2482	.0274	6.9313	.0070
115	.0295	6.5885	.0077	334	18.2756	.0274	6.9383	.0068
410	.0295	6.5962	.0076	335	18.3030	.0273	6.9451	.0069
705	.0295	6.6038	.0076	336	18.3303	.0272	6.9520	.0069
000	.0293	6.6114	.0077	337	18.3575	.0272	6.9589	.0069
293	.0294	6.6191	.0076	338	18.3847	.0272	6.9658	.0068
587	.0293	6.6267	.0075	339	18.4119	.0271	6.9726	.0069
880	.0292	6.6342	.0076	340	18.4390	.0271	6.9795	.0068
172	.0292	6.6418	.0075	341	18.4661	.0271	6.9863	.0068
464	.0291	6.6493	.0076	342	18.4932	.0270	6.9931	.0069
755	.0291	6.6569	.0075	343	18.5202	.0270	7.0000	.0067
046	.0290	6.6644	.0075	344	18.5472	.0269	7.0067	.0068
336	.0290	6.6719	.0075	345	18.5741	.0269	7.0135	.0068
626	.0290	6.6794	.0074	346	18.6010	.0269	7.0203	.0068
916	.0289	6.6868	.0075	347	18.6279	.0268	7.0271	.0067
205	.0288	6.6943	.0074	348	18.6547	.0268	7.0338	.0067
493	.0288	6.7017	.0074	349	18.6815	.0267	7.0405	.0067
781	.0287	6.7091	.0074	350	18.7082	.0267	7.0472	.0068
068	.0287	6.7165	.0074	351	18.7349	.0267	7.0540	.0066
355	.0287	6.7239	.0074	352	18.7616	.0267	7.0606	.0067
642	.0286	6.7313	.0073	353	18.7882	.0266	7.0673	.0067
928	.0286	6.7386	.0073	354	18.8148	.0266	7.0740	.0066
214	.0285	6.7459	.0074	355	18.8414	.0266	7.0806	.0067
499	.0284	6.7533	.0073	356	18.8679	.0265	7.0873	.0066
783	.0285	6.7606	.0072	357	18.8944	.0264	7.0939	.0066
068	.0283	6.7678	.0073	358	18.9208	.0264	7.1005	.0066
351	.0284	6.7751	.0073	359	18.9472	.0264	7.1071	.0066
635	.0283	6.7824	.0072	360	18.9736	.0264	7.1137	.0066
918	.0282	6.7896	.0072	361	19.0000	.0262	7.1203	.0066
200	.0282	6.7968	.0072	362	19.0262	.0263	7.1269	.0065
482	.0281	6.8040	.0072	363	19.0525	.0262	7.1334	.0066
763	.0281	6.8112	.0072	364	19.0787	.0262	7.1400	.0065
044	.0281	6.8184	.0072	365	19.1049	.0262	7.1465	.0065
325	.0280	6.8256	.0071	366	19.1311	.0261	7.1530	.0065
605	.0280	6.8327	.0072	367	19.1572	.0261	7.1595	.0065
885	.0279	6.8399	.0071	368	19.1833	.0260	7.1660	.0065
164	.0279	6.8470	.0071	369	19.2093	.0260	7.1725	.0065
443	.0279	6.8541	.0071	370	19.2353	.0260	7.1790	.0065
722	.0278	6.8612	.0070	371	19.2613	.0260	7.1855	.0064
000	.0277	6.8682	.0071	372	19.2873	.0259	7.1919	.0065
277	.0277	6.8753	.0070	373	19.3132	.0258	7.1984	.0064
554	.0277	6.8823	.0071	374	19.3390	.0259	7.2048	.0064
831	.0276	6.8894	.0070	375	19.3649	.0258	7.2112	.0064
107	.0276	6.8964	.0070	376	19.3907	.0257	7.2176	.0064
383	.0276	6.9034	.0070	377	19.4164	.0257	7.2240	.0064

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
377	19.4164	.0258	7.2240	.0064	425	20.6155	.0242	7.5184	.0059
378	19.4422	.0257	7.2304	.0063	426	20.6397	.0242	7.5243	.0059
379	19.4679	.0256	7.2367	.0064	427	20.6639	.0242	7.5302	.0059
380	19.4935	.0257	7.2431	.0064	428	20.6881	.0242	7.5361	.0059
381	19.5192	.0256	7.2495	.0063	429	20.7123	.0241	7.5419	.0058
382	19.5448	.0255	7.2558	.0063	430	20.7364	.0241	7.5478	.0059
383	19.5703	.0256	7.2621	.0063	431	20.7605	.0241	7.5536	.0059
384	19.5959	.0255	7.2684	.0063	432	20.7846	.0240	7.5595	.0058
385	19.6214	.0254	7.2747	.0063	433	20.8086	.0240	7.5653	.0058
386	19.6468	.0255	7.2810	.0063	434	20.8326	.0240	7.5711	.0058
387	19.6723	.0254	7.2873	.0063	435	20.8566	.0240	7.5769	.0058
388	19.6977	.0253	7.2936	.0062	436	20.8806	.0239	7.5827	.0058
389	19.7230	.0254	7.2998	.0063	437	20.9045	.0239	7.5885	.0058
390	19.7484	.0253	7.3061	.0062	438	20.9284	.0239	7.5943	.0058
391	19.7737	.0252	7.3123	.0063	439	20.9523	.0238	7.6001	.0058
392	19.7989	.0253	7.3186	.0062	440	20.9761	.0239	7.6059	.0057
393	19.8242	.0252	7.3248	.0062	441	21.0000	.0237	7.6116	.0058
394	19.8494	.0252	7.3310	.0062	442	21.0237	.0237	7.6174	.0057
395	19.8746	.0252	7.3372	.0062	443	21.0457	.0220	7.6231	.0057
396	19.8997	.0251	7.3434	.0061	444	21.0713	.0256	7.6288	.0058
397	19.9248	.0251	7.3495	.0062	445	21.0950	.0237	7.6346	.0057
398	19.9499	.0251	7.3557	.0062	446	21.1187	.0237	7.6403	.0057
399	19.9749	.0250	7.3619	.0061	447	21.1423	.0236	7.6460	.0057
400	20.0000	.0251	7.3680	.0061	448	21.1660	.0237	7.6517	.0057
401	20.0249	.0249	7.3741	.0062	449	21.1896	.0236	7.6574	.0056
402	20.0499	.0250	7.3803	.0061	450	21.2132	.0236	7.6630	.0057
403	20.0748	.0249	7.3864	.0061	451	21.2367	.0235	7.6687	.0057
404	20.0997	.0249	7.3925	.0061	452	21.2602	.0235	7.6744	.0056
405	20.1246	.0248	7.3986	.0061	453	21.2837	.0235	7.6800	.0057
406	20.1494	.0248	7.4047	.0060	454	21.3072	.0235	7.6857	.0056
407	20.1742	.0248	7.4107	.0061	455	21.3307	.0234	7.6913	.0057
408	20.1990	.0247	7.4168	.0061	456	21.3541	.0234	7.6970	.0056
409	20.2237	.0247	7.4229	.0060	457	21.3775	.0234	7.7026	.0056
410	20.2484	.0247	7.4289	.0060	458	21.4009	.0233	7.7082	.0056
411	20.2731	.0246	7.4349	.0061	459	21.4242	.0234	7.7138	.0056
412	20.2977	.0247	7.4410	.0060	460	21.4476	.0233	7.7194	.0056
413	20.3224	.0245	7.4470	.0060	461	21.4709	.0232	7.7250	.0056
414	20.3469	.0246	7.4530	.0060	462	21.4941	.0233	7.7306	.0055
415	20.3715	.0245	7.4590	.0060	463	21.5174	.0232	7.7361	.0056
416	20.3960	.0245	7.4650	.0059	464	21.5406	.0232	7.7417	.0056
417	20.4205	.0245	7.4709	.0060	465	21.5638	.0232	7.7473	.0055
418	20.4450	.0244	7.4769	.0060	466	21.5870	.0231	7.7528	.0056
419	20.4694	.0245	7.4829	.0059	467	21.6101	.0232	7.7584	.0055
420	20.4939	.0243	7.4888	.0060	468	21.6333	.0231	7.7639	.0055
421	20.5182	.0244	7.4948	.0059	469	21.6564	.0230	7.7694	.0055
422	20.5426	.0243	7.5007	.0059	470	21.6794	.0231	7.7749	.0055
423	20.5669	.0243	7.5066	.0059	471	21.7025	.0230	7.7804	.0055
424	20.5912	.0243	7.5125	.0059	472	21.7255	.0230	7.7859	.0055
425	20.6155		7.5184		473	21.7485		7.7914	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
473	21.7485	.0230	7.7914	.0055	521	22.8254	.0219	8.0466	.0051
474	21.7715	.0229	7.7969	.0055	522	22.8473	.0218	8.0517	.0051
475	21.7944	.0230	7.8024	.0055	523	22.8691	.0219	8.0568	.0052
476	21.8174	.0229	7.8079	.0055	524	22.8910	.0218	8.0620	.0051
477	21.8403	.0229	7.8133	.0054	525	22.9128	.0218	8.0671	.0051
478	21.8632	.0228	7.8188	.0055	526	22.9346	.0218	8.0722	.0051
479	21.8860	.0229	7.8242	.0054	527	22.9564	.0218	8.0773	.0051
480	21.9089	.0228	7.8297	.0055	528	22.9782	.0218	8.0824	.0051
481	21.9317	.0227	7.8351	.0054	529	23.0000	.0217	8.0875	.0051
482	21.9544	.0228	7.8405	.0054	530	23.0217	.0217	8.0926	.0051
483	21.9772	.0228	7.8460	.0055	531	23.0434	.0217	8.0977	.0051
484	22.0000	.0227	7.8514	.0054	532	23.0651	.0216	8.1028	.0051
485	22.0227	.0227	7.8568	.0054	533	23.0867	.0217	8.1079	.0050
486	22.0454	.0226	7.8622	.0054	534	23.1084	.0216	8.1129	.0051
487	22.0680	.0227	7.8676	.0054	535	23.1300	.0216	8.1180	.0050
488	22.0907	.0226	7.8729	.0053	536	23.1516	.0216	8.1230	.0051
489	22.1133	.0226	7.8783	.0054	537	23.1732	.0216	8.1281	.0050
490	22.1359	.0226	7.8837	.0054	538	23.1948	.0215	8.1331	.0051
491	22.1585	.0226	7.8890	.0053	539	23.2163	.0216	8.1382	.0050
492	22.1810	.0225	7.8944	.0054	540	23.2379	.0215	8.1432	.0050
493	22.2036	.0226	7.8997	.0054	541	23.2594	.0214	8.1482	.0050
494	22.2261	.0225	7.9051	.0053	542	23.2808	.0215	8.1532	.0051
495	22.2485	.0224	7.9104	.0054	543	23.3023	.0215	8.1583	.0050
496	22.2710	.0225	7.9157	.0053	544	23.3238	.0214	8.1633	.0050
497	22.2934	.0224	7.9210	.0053	545	23.3452	.0214	8.1683	.0050
498	22.3159	.0225	7.9264	.0054	546	23.3666	.0214	8.1733	.0050
499	22.3383	.0224	7.9317	.0053	547	23.3880	.0213	8.1782	.0049
500	22.3606	.0223	7.9370	.0053	548	23.4093	.0214	8.1832	.0050
501	22.3830	.0224	7.9422	.0052	549	23.4307	.0213	8.1882	.0050
502	22.4053	.0223	7.9475	.0053	550	23.4520	.0213	8.1932	.0049
503	22.4276	.0223	7.9528	.0053	551	23.4733	.0213	8.1981	.0050
504	22.4499	.0223	7.9581	.0052	552	23.4946	.0213	8.2031	.0049
505	22.4722	.0222	7.9633	.0053	553	23.5159	.0213	8.2080	.0050
506	22.4944	.0222	7.9686	.0052	554	23.5372	.0212	8.2130	.0049
507	22.5166	.0222	7.9738	.0053	555	23.5584	.0212	8.2179	.0049
508	22.5388	.0222	7.9791	.0052	556	23.5796	.0212	8.2229	.0050
509	22.5610	.0222	7.9843	.0052	557	23.6008	.0212	8.2278	.0049
510	22.5831	.0221	7.9895	.0052	558	23.6220	.0211	8.2327	.0049
511	22.6053	.0222	7.9947	.0053	559	23.6431	.0212	8.2376	.0049
512	22.6274	.0221	8.0000	.0052	560	23.6643	.0211	8.2425	.0049
513	22.6495	.0221	8.0052	.0052	561	23.6854	.0211	8.2474	.0049
514	22.6715	.0220	8.0104	.0051	562	23.7065	.0211	8.2523	.0049
515	22.6936	.0221	8.0155	.0052	563	23.7276	.0210	8.2572	.0049
516	22.7156	.0220	8.0207	.0052	564	23.7486	.0211	8.2621	.0049
517	22.7376	.0220	8.0259	.0052	565	23.7697	.0210	8.2670	.0049
518	22.7596	.0220	8.0311	.0051	566	23.7907	.0210	8.2719	.0049
519	22.7815	.0219	8.0362	.0052	567	23.8117	.0210	8.2767	.0048
520	22.8035	.0219	8.0414	.0052	568	23.8327	.0210	8.2816	.0049
521	22.8254		8.0466		569	23.8537		8.2864	.004

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
569	23.8537	.0209	8.2864	.0049	617	24.8394	.0202	8.5132	.0046
570	23.8746	.0210	8.2913	.0048	618	24.8596	.0201	8.5178	.0046
571	23.8956	.0209	8.2961	.0049	619	24.8797	.0200	8.5224	.0046
572	23.9165	.0209	8.3010	.0048	620	24.8997	.0201	8.5270	.0046
573	23.9374	.0208	8.3058	.0048	621	24.9198	.0201	8.5316	.0045
574	23.9582	.0209	8.3106	.0049	622	24.9399	.0200	8.5361	.0046
575	23.9791	.0209	8.3155	.0048	623	24.9599	.0200	8.5407	.0046
576	24.0000	.0208	8.3203	.0048	624	24.9799	.0201	8.5453	.0045
577	24.02 8	.0208	8.3251	.0048	625	25.00 0	.0199	8.5498	.0046
578	24 0416	.0208	8.3299	.0048	626	25.0199	.0200	8.5544	.0045
579	24.0624	.0207	8.3347	.0048	627	25.0399	.0200	8.5589	.0046
580	24.0831	.0208	8.3395	.0 48	628	25.0599	.0199	8.5635	.0045
581	24.1039	.0207	8.3443	.0048	629	25.0798	.0200	8.5680	.0046
582	24.1246	.0207	8.3491	.0048	630	25.0998	.0209	8.5726	.0045
583	24.1453	.0207	8.3539	.0047	631	25.1197	.0199	8.5771	.0045
584	24.1660	.0207	8.3586	.0048	632	25.1396	.0198	8 5816	.0046
585	24.1867	.0207	8.3634	.0048	633	25.1594	.0199	8.5862	.0045
586	24.2074	.0206	8.3682	.0047	634	25.1793	.0199	8.5907	.0045
587	24.2280	.0207	8.3729	.0048	635	25.1992	.0198	8.5952	.0045
588	24.2487	.0206	8.3777	.0047	636	25.2190	.0198	8.5997	.0045
589	24.2693	.0206	8.3824	.0048	637	25.2388	.0198	8.6042	.0045
590	24.2899	.0205	8.3872	.0047	638	25.2586	.0198	8.6087	.0045
591	24.3104	.0206	8.3919	.0047	639	25.2784	.0198	8.6132	.0045
592	24.3310	.0205	8.3966	.0047	640	25.2982	.0198	8.6177	.0045
593	24.3515	.0206	8.4013	.0048	641	25 3179	.0197	8.6222	.0045
594	24.3721	.0205	8.4061	.0047	642	25.3377	.0198	8.6267	.0044
595	24.3926	.0205	8.4108	.0047	643	25.3574	.0197	8.6311	.0045
596	24.4131	.0204	8.4155	.0047	644	25.3771	.0197	8.6356	.0045
597	24.4335	.0205	8.4202	.0047	645	25.3968	.0197	8.6401	.0044
598	24.4540	.0204	8.4249	.0047	646	25.4165	.0196	8.6445	.0045
599	24.4744	.0204	8.4296	.0047	647	25.4361	.0197	8.6490	.0044
600	24.4948	.0205	8.4343	.0047	648	25.4558	.0196	8.6534	.0045
601	24.5153	.0203	8.4390	.0046	649	25.4754	.0196	8.6579	.0044
602	24.5356	.0204	8.4436	.0047	650	25.4950	.0197	8.6623	.0045
603	24.5560	.0204	8.4483	.0047	651	25.5147	.0195	8.6668	.0044
604	24.5764	.0203	8.4530	.0046	652	25.5342	.0196	8.6712	.0044
605	24.5967	.0203	8.4576	.0047	653	25.5538	.0196	8.6756	.0045
606	24.6170	.0203	8.4623	.0047	654	25.5734	.0195	8.6801	.0044
607	24.6373	.0203	8.4670	.0046	655	25.5929	.0195	8.6845	.0044
608	24.6576	.0203	8.4716	.0046	656	25.6124	.0195	8.6889	.0044
609	24.8779	.0202	8.4762	.0047	657	25.6320	.0195	8.6933	.0044
610	24.6981	.0203	8.4809	.0046	658	25.6515	.0194	8.6977	.0044
611	24.7184	.0202	8.4855	.0046	659	25.6709	.0195	8.7021	.0044
612	24.7386	.0202	8.4901	.0047	660	25.6904	.0195	8.7065	.0044
613	24.7588	.0202	8.4948	.0046	661	25.7099	.0194	8.7109	.0044
614	24.7790	.0201	8.4994	.0046	662	25.7293	.0194	8.7153	.0044
615	24.7991	.0202	8.5040	.0046	663	25.7487	.0194	8.7197	.0044
616	24.8193	.0201	8.5086	.0046	664	25.7681	.0194	8.7241	.0044
617	24.8394		8.5132		665	25.7875		8.7285	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
665	25.7875	.0194	8.7285	.0043	713	26.7020	.0187	8.9336	.0042
666	25.8069	.0194	8.7328	.0044	714	26.7207	.0187	8.9378	.0042
667	25.8263	.0193	8.7372	.0044	715	26.7394	.0187	8.9420	.0041
668	25.8456	.0194	8.7416	.0043	716	26.7581	.0187	8.9461	.0042
669	25.8650	.0193	8.7459	.0044	717	26.7768	.0187	8.9503	.0042
670	25.8843	.0193	8.7503	.0043	718	26.7955	.0186	8.9545	.0041
671	25.9036	.0193	8.7546	.0044	719	26.8141	.0187	8.9586	.0042
672	25.9229	.0193	8.7590	.0043	720	26.8328	.0186	8.9628	.0041
673	25.9422	.0193	8.7633	.0044	721	26.8514	.0186	8.9669	.0042
674	25.9615	.0192	8.7677	.0043	722	26.8700	.0186	8.9711	.0041
675	25.9807	.0193	8.7720	.0043	723	26.8886	.0186	8.9752	.0041
676	26.0000	.0192	8.7763	.0044	724	26.9072	.0186	8.9793	.0042
677	26.0192	.0192	8.7807	.0043	725	26.9258	.0185	8.9835	.0041
678	26.0384	.0192	8.7850	.0043	726	26.9443	.0186	8.9876	.0041
679	26.0576	.0192	8.7893	.0043	727	26.9629	.0185	8.9917	.0041
680	26.0768	.0191	8.7936	.0043	728	26.9814	.0186	8.9958	.0042
681	26.0959	.0192	8.7979	.0043	729	27.0000	.0185	9.0000	.0041
682	26.1151	.0191	8.8022	.0043	730	27.0185	.0185	9.0041	.0041
683	26.1342	.0191	8.8065	.0043	731	27.0370	.0184	9.0082	.0041
684	26.1533	.0192	8.8108	.0043	732	27.0554	.0185	9.0123	.0041
685	26.1725	.0191	8.8151	.0043	733	27.0739	.0185	9.0164	.0041
686	26.1916	.0190	8.8194	.0043	734	27.0924	.0184	9.0205	.0041
687	26.2106	.0191	8.8237	.0043	735	27.1108	.0185	9.0246	.0041
688	26.2297	.0191	8.8280	.0042	736	27.1293	.0184	9.0287	.0041
689	26.2488	.0190	8.8322	.0043	737	27.1477	.0184	9.0328	.0040
690	26.2678	.0190	8.8365	.0043	738	27.1661	.0184	9.0368	.0041
691	26.2868	.0190	8.8408	.0042	739	27.1845	.0184	9.0409	.0041
692	26.3058	.0190	8.8450	.0043	740	27.2029	.0184	9.0450	.0041
693	26.3248	.0190	8.8493	.0042	741	27.2213	.0183	9.0491	.0040
694	26.3438	.0190	8.8535	.0043	742	27.2396	.0184	9.0531	.0041
695	26.3628	.0190	8.8578	.0042	743	27.2580	.0183	9.0572	.0041
696	26.3818	.0189	8.8620	.0043	744	27.2763	.0183	9.0613	.0040
697	26.4007	.0189	8.8663	.0042	745	27.2946	.0184	9.0653	.0041
698	26.4196	.0189	8.8705	.0043	746	27.3130	.0183	9.0694	.0040
699	26.4386	.0189	8.8748	.0042	747	27.3313	.0182	9.0734	.0041
700	26.4575	.0189	8.8790	.0042	748	27.3495	.0183	9.0775	.0040
701	26.4764	.0188	8.8832	.0042	749	27.3678	.0183	9.0815	.0041
702	26.4952	.0189	8.8874	.0043	750	27.3861	.0182	9.0856	.0040
703	26.5141	.0188	8.8917	.0042	751	27.4043	.0183	9.0896	.0040
704	26.5329	.0189	8.8959	.0042	752	27.4226	.0182	9.0936	.0041
705	26.5518	.0188	8.9001	.0042	753	27.4408	.0182	9.0977	.0040
706	26.5706	.0188	8.9043	.0042	754	27.4590	.0182	9.1017	.0040
707	26.5894	.0188	8.9085	.0042	755	27.4772	.0182	9.1057	.0040
708	26.6082	.0188	8.9127	.0042	756	27.4954	.0182	9.1097	.0040
709	26.6270	.0188	8.9169	.0042	757	27.5136	.0181	9.1137	.0040
710	26.6458	.0187	8.9211	.0042	758	27.5317	.0182	9.1177	.0041
711	26.6645	.0188	8.9253	.0041	759	27.5499	.0181	9.1218	.0040
712	26.6833	.0187	8.9294	.0042	760	27.5680	.0182	9.1258	.0040
713	26.7020		8.9336		761	27.5862		9.1298	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
761	27.5862	.0181	9.1298	.0040	809	28.4429	.0175	9.3178	.0038
762	27.6043	.0181	9.1338	.0039	810	28.4604	.0176	9.3216	.0039
763	27.6224	.0181	9.1377	.0040	811	28.4780	.0176	9.3255	.0038
764	27.6405	.0181	9.1417	.0040	812	28.4956	.0175	9.3293	.0038
765	27.6586	.0181	9.1457	.0040	813	28.5131	.0175	9.3331	.0039
766	27.6767	.0180	9.1497	.0040	814	28.5306	.0176	9.3370	.0038
767	27.6947	.0181	9.1537	.0040	815	28.5482	.0175	9.3408	.0038
768	27.7128	.0180	9.1577	.0039	816	28.5657	.0175	9.3446	.0038
769	27.7308	.0180	9.1616	.0040	817	28.5832	.0174	9.3484	.0038
770	27.7488	.0180	9.1656	.0040	818	28.6006	.0175	9.3522	.0038
771	27.7668	.0180	9.1696	.0039	819	28.6181	.0175	9.3560	.0039
772	27.7848	.0180	9.1735	.0040	820	28.6356	.0174	9.3599	.0038
773	27.8028	.0180	9.1775	.0040	821	28.6530	.0175	9.3637	.0038
774	27.8208	.0180	9.1815	.0039	822	28.6705	.0174	9.3675	.0038
775	27.8388	.0179	9.1854	.0040	823	28.6879	.0175	9.3713	.0037
776	27.8567	.0180	9.1894	.0039	824	28.7054	.0174	9.3750	.0038
777	27.8747	.0179	9.1933	.0039	825	28.7228	.0174	9.3788	.0038
778	27.8926	.0179	9.1972	.0040	826	28.7402	.0174	9.3826	.0038
779	27.9105	.0179	9.2012	.0039	827	28.7576	.0173	9.3864	.0038
780	27.9284	.0179	9.2051	.0039	828	28.7749	.0174	9.3902	.0038
781	27.9463	.0179	9.2090	.0040	829	28.7923	.0174	9.3940	.0037
782	27.9642	.0179	9.2130	.0039	830	28.8097	.0173	9.3977	.0038
783	27.9821	.0179	9.2169	.0039	831	28.8270	.0174	9.4015	.0038
784	28.0000	.0178	9.2208	.0039	832	28.8444	.0173	9.4053	.0038
785	28.0178	.0178	9.2247	.0040	833	28.8617	.0173	9.4091	.0037
786	28.0356	.0179	9.2287	.0039	834	28.8790	.0173	9.4128	.0038
787	28.0535	.0178	9.2326	.0039	835	28.8963	.0173	9.4166	.0037
788	28.0713	.0178	9.2365	.0039	836	28.9136	.0173	9.4203	.0038
789	28.0891	.0178	9.2404	.0039	837	28.9309	.0173	9.4241	.0037
790	28.1069	.0176	9.2443	.0039	838	28.9482	.0172	9.4278	.0038
791	28.1247	.0177	9.2482	.0039	839	28.9654	.0173	9.4316	.0037
792	28.1424	.0178	9.2521	.0039	840	28.9827	.0173	9.4353	.0038
793	28.1602	.0178	9.2560	.0039	841	29.0000	.0172	9.4391	.0037
794	28.1780	.0177	9.2599	.0038	842	29.0172	.0172	9.4428	.0038
795	28.1957	.0177	9.2637	.0039	843	29.0344	.0172	9.4466	.0037
796	28.2134	.0177	9.2676	.0039	844	29.0516	.0172	9.4503	.0037
797	28.2311	.0177	9.2715	.0039	845	29.0688	.0172	9.4540	.0037
798	28.2488	.0177	9.2754	.0039	846	29.0860	.0172	9.4577	.0038
799	28.2665	.0177	9.2793	.0038	847	29.1032	.0172	9.4615	.0037
800	28.2842	.0177	9.2831	.0039	848	29.1204	.0172	9.4652	.0037
801	28.3019	.0177	9.2870	.0039	849	29.1376	.0171	9.4689	.0037
802	28.3196	.0176	9.2909	.0038	850	29.1547	.0172	9.4726	.0036
803	28.3372	.0176	9.2947	.0039	851	29.1719	.0171	9.4761	.0040
804	28.3548	.0177	9.2986	.0038	852	29.1890	.0171	9.4801	.0037
805	28.3725	.0176	9.3024	.0039	853	29.2061	.0171	9.4838	.0037
806	28.3901	.0176	9.3063	.0038	854	29.2232	.0171	9.4875	.0037
807	28.4077	.0176	9.3101	.0039	855	29.2403	.0171	9.4912	.0037
808	28.4253	.0176	9.3140	.0038	856	29.2574	.0171	9.4949	.0037
809	28.4429		9.3178		857	29.2745		9.4986	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
857	29.2745	.0171	9.4986	.0037	905	30.0832	.0166	9.6727	.0036
858	29.2916	.0171	9.5023	.0036	906	30.0998	.0166	9.6763	.0035
859	29.3087	.0170	9.5059	.0037	907	30.1164	.0166	9.6798	.0036
860	29.3257	.0171	9.5096	.0037	908	30.1330	.0166	9.6834	.0035
861	29.3428	.0170	9.5133	.0037	909	30.1496	.0166	9.6869	.0036
862	29.3598	.0170	9.5170	.0037	910	30.1662	.0165	9.6905	.0035
863	29.3768	.0170	9.5207	.0037	911	30.1827	.0166	9.6940	.0036
864	29.3938	.0170	9.5244	.0036	912	30.1993	.0165	9.6976	.0035
865	29.4108	.0170	9.5280	.0037	913	30.2158	.0166	9.7011	.0035
866	29.4278	.0170	9.5317	.0037	914	30.2324	.0165	9.7046	.0036
867	29.4448	.0170	9.5354	.0036	915	30.2489	.0165	9.7082	.0035
868	29.4618	.0170	9.5390	.0037	916	30.2654	.0166	9.7117	.0036
869	29.4788	.0169	9.5427	.0037	917	30.2820	.0165	9.7153	.0035
870	29.4957	.0170	9.5464	.0036	918	30.2985	.0165	9.7188	.0035
871	29.5127	.0169	9.5500	.0037	919	30.3150	.0165	9.7223	.0035
872	29.5296	.0169	9.5537	.0036	920	30.3315	.0164	9.7258	.0036
873	29.5465	.0169	9.5573	.0037	921	30.3479	.0165	9.7294	.0035
874	29.5634	.0169	9.5610	.0036	922	30.3644	.0165	9.7329	.0035
875	29.5803	.0169	9.5646	.0036	923	30.3809	.0164	9.7364	.0035
876	29.5972	.0169	9.5682	.0037	924	30.3973	.0165	9.7399	.0035
877	29.6141	.0169	9.5719	.0036	925	30.4138	.0164	9.7434	.0035
878	29.6310	.0169	9.5755	.0037	926	30.4302	.0164	9.7469	.0035
879	29.6479	.0168	9.5792	.0036	927	30.4466	.0164	9.7504	.0035
880	29.6647	.0169	9.5828	.0036	928	30.4630	.0165	9.7539	.0036
881	29.6816	.0168	9.5864	.0036	929	30.4795	.0164	9.7575	.0035
882	29.6984	.0169	9.5900	.0037	930	30.4959	.0163	9.7610	.0044
883	29.7153	.0168	9.5937	.0036	931	30.5122	.0164	9.7644	.0035
884	29.7321	.0168	9.5973	.0036	932	30.5286	.0164	9.7679	.0035
885	29.7489	.0168	9.6009	.0036	933	30.5450	.0164	9.7714	.0035
886	29.7657	.0168	9.6045	.0036	934	30.5614	.0163	9.7749	.0035
887	29.7825	.0168	9.6081	.0036	935	30.5777	.0164	9.7784	.0035
888	29.7993	.0168	9.6117	.0036	936	30.5941	.0163	9.7829	.0035
889	29.8161	.0167	9.6153	.0037	937	30.6104	.0163	9.7854	.0035
890	29.8328	.0168	9.6190	.0036	938	30.6267	.0164	9.7889	.0034
891	29.8496	.0167	9.6226	.0036	939	30.6431	.0163	9.7923	.0035
892	29.8663	.0168	9.6262	.0035	940	30.6594	.0163	9.7958	.0035
893	29.8831	.0167	9.6297	.0036	941	30.6757	.0163	9.7993	.0035
894	29.8998	.0167	9.6333	.0036	942	30.6920	.0163	9.8028	.0034
895	29.9165	.0167	9.6369	.0036	943	30.7083	.0162	9.8062	.0035
896	29.9332	.0167	9.6405	.0036	944	30.7245	.0163	9.8097	.0034
897	29.9499	.0167	9.6441	.0036	945	30.7408	.0163	9.8131	.0035
898	29.9666	.0167	9.6477	.0036	946	30.7571	.0162	9.8166	.0035
899	29.9833	.0167	9.6513	.0035	947	30.7733	.0163	9.8201	.0034
900	30.0000	.0166	9.6548	.0036	948	30.7896	.0162	9.8235	.0035
901	30.0166	.0167	9.6584	.0036	949	30.8058	.0162	9.8270	.0034
902	30.0333	.0166	9.6620	.0036	950	30.8220	.0162	9.8304	.0035
903	30.0499	.0166	9.6656	.0035	951	30.8382	.0162	9.8339	.0034
904	30.0665	.0167	9.6691	.0036	952	30.8544	.0162	9.8373	.0035
905	30.0832		9.6727		953	30.8706		9.8408	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
953	30.8706	.0162	9.8408	.0034	977	31.2569	.0160	9.9227	.0034
954	30.8868	.0162	9.8442	.0034	978	31.2729	.0160	9.9261	.0034
955	30.9030	.0162	9.8476	.0035	979	31.2889	.0160	6.9295	.0033
956	30.9192	.0162	9.8511	.0034	980	31.3049	.0160	9.9328	.0034
957	30.9354	.0161	9.8545	.0034	981	31.3209	.0159	9.9362	.0034
958	30.9515	.0162	9.8579	.0035	982	31.3368	.0160	9.9396	.0034
959	30.9677	.0161	9.8614	.0034	983	31.3528	.0159	9.9430	.0033
960	30.9838	.0162	9.8648	.0034	984	31.3687	.0160	9.9463	.0034
961	31.0000	.0161	9.8682	.0034	985	31.3847	.0159	9.9497	.0034
962	31.0161	.0161	9.8716	.0035	986	31.4006	.0159	9.9531	.0033
963	31.0322	.0161	9.8751	.0034	987	31.4165	.0159	9.9564	.0034
964	31.0483	.0161	9.8785	.0034	988	31.4324	.0159	9.9598	.0033
965	31.0644	.0161	9.8819	.0034	989	31.4483	.0159	9.9631	.0034
966	31.0805	.0161	9.8853	.0034	990	31.4642	.0159	9.9665	.0034
967	31.0966	.0160	9.8887	.0034	991	31.4801	.0159	9.9699	.0033
968	31.1126	.0161	9.8921	.0034	992	31.4960	.0159	9.9732	.0034
969	31.1287	.0161	9.8955	.0034	993	31.5119	.0158	9.9766	.0033
970	31.1448	.0160	9.8989	.0034	994	31.5277	.0159	9.9799	.0034
971	31.1608	.0161	9.9023	.0034	995	31.5436	.0158	9.9833	.0033
972	31.1769	.0160	9.9057	.0034	996	31.5594	.0159	9.9866	.0033
973	31.1929	.0160	9.9091	.0034	997	31.5753	.0158	9.9899	.0034
974	31.2089	.0160	9.9125	.0034	998	31.5911	.0158	9.9933	.0033
975	31.2249	.0160	9.9159	.0034	999	31.6069	.0158	9.9966	.0034
976	31.2409	.0160	9.9193	.0034	1000	31.6227		10.0000	
977	31.2569		9.9227						

TABLE

CONTAINING

THE SURFACE AND SOLIDITY OF SPHERES,

The Edge or Dimensions of Equal Cubes,

THE LENGTHS OF EQUAL CYLINDERS,

AND THE

WEIGHT OF EQUAL QUANTITIES OF WATER IN AVOIRDUPOIS LBS.

Dia.	Surface.	Solidity.	Cube.	Cylinder.	Water in lbs.
1 *in.*	3.1416	.5236	.8060	.6666	.0190
1/16	3.5465	.6280	.8563	.7082	.0227
1/8	3.9760	.7455	.9067	.7500	.0270
3/16	4.4301	.8767	.9571	.7917	.0317
1/4	4.9087	1.0226	1.0075	.8333	.0370
5/16	5.4117	1.1838	1.0578	.8750	.0428
3/8	5.9395	1.3611	1.1082	.9166	.0500
7/16	6.4918	1.5553	1.1586	.9583	.0563
1/2	7.0686	1.7671	1.2090	1.0000	.0640
9/16	7.6699	2.0000	1.2593	1.0416	.0723
5/8	8.2957	2.2467	1.3097	1.0833	.0813
11/16	8.9461	2.5161	1.3601	1.1349	.0910
3/4	9.6211	2.8061	1.4105	1.1666	.1015
13/16	10.3206	3.1176	1.4608	1.2083	.1128
7/8	11.0446	3.4514	1.5112	1.2500	.1250
15/16	11.7932	3.8081	1.5616	1.2916	.1377
2 *in.*	12.5664	4.1888	1.6020	1.3333	.1516
1/16	13.3640	4.5938	1.6633	1.3750	.1662
1/8	14.1862	5.0243	1.7127	1.4166	.1818
3/16	15.0330	5.4807	1.7631	1.4582	.1982
1/4	15.9043	5.9640	1.8135	1.5000	.2160
5/16	16.8000	6.4749	1.8638	1.5516	.2342
3/8	17.7205	7.0143	1.9142	1.5832	.2540
7/16	18.6655	7.5828	1.9646	1.6250	.2743
1/2	19.6350	8.1812	2.0150	1.6666	.2960
9/16	20.6290	8.8103	2.0653	1.7082	.3187
5/8	21.6475	9.4708	2.1157	1.7500	.3426
11/16	22.6907	10.1634	2.1661	1.7915	.3676
3/4	23.7583	10.8892	2.2165	1.8332	.3939
13/16	24.8505	11.6485	2.2668	1.8750	.4213
7/8	25.9672	12.4426	2.3172	1.9165	.4501
15/16	27.1085	13.2718	2.3676	1.9582	.4800
3 *in.*	28.2744	14.1372	2.4180	2.0000	.5114
1/16	29.4647	15.0392	2.4683	2.0415	.5440
1/8	30.6796	15.9790	2.5187	2.0832	.5780
3/16	31.9191	16.9570	2.5691	2.1250	.6133
1/4	33.1831	17.9742	2.6195	2.1665	.6401
5/16	35.3715	19.0311	2.6698	2.2082	.6884
3/8	35.7847	20.1289	2.7202	2.2500	.7281
7/16	37.1224	21.2680	2.7706	2.2915	.7693
1/2	38.4846	22.4493	2.8210	2.3332	.8120
9/16	39.8713	23.6735	2.8713	2.3750	.8561
5/8	41.2825	24.9415	2.9217	2.4166	.9021
11/16	42.7183	26.2539	2.9712	2.4582	.9496
3/4	44.1787	27.6117	3.0225	2.5000	.9987
13/16	45.6636	29.0102	3.0728	2.5415	1.0493
7/8	47.1730	30.4659	3.1232	2.5832	1.1020
15/16	48.7070	31.9640	3.1730	2.6250	1.1561

Dia.	Surface.	Solidity.	Cube.	Cylinder.	Water in lbs.
4 *in.*	50.2656	33.5104	3.2240	2.6665	1.1974
1/16	51.8486	35.1058	3.2743	2.7082	1.2698
1/8	53.4562	36.7511	3.3247	2.7500	1.3293
3/16	55.0884	38.4471	3.3751	2.7915	1.3906
1/4	56.7451	40.1944	3.4255	2.8332	1.4538
5/16	58.4262	42.0461	3.4758	2.8750	1.5208
3/8	60.1321	43.8463	3.5262	2.9165	1.5860
7/16	61.8625	45.7524	3.5766	2.9582	1.6550
1/2	63.6174	47.7127	3.6270	3.0000	1.7258
9/16	65.3968	49.7290	3.6773	3.0415	1.7987
5/8	67.2007	51.8006	3.7277	3.0832	1.8736
11/16	69.0352	53.9290	3.7781	3.1250	1.9506
3/4	70.8823	56.1151	3.8285	3.1665	2.0297
13/16	72.7599	58.3595	3.8788	3.2080	2.1109
7/8	74.6620	60.6629	3.9292	3.2500	2.1942
15/16	76.5887	62.9261	3.9796	3.2913	2.2760
5 *in.*	78.5400	65.4500	4.0300	3.3332	2.3673
1/16	80.5157	67.9351	4.0803	3.3750	2.4572
1/8	82.5160	70.4824	4.1307	3.4155	2.5453
3/16	84.5409	73.0926	4.1811	3.4582	2.6438
1/4	86.5903	75.7664	4.2315	3.5000	2.7605
5/16	88.6641	78.5077	4.2818	3.5414	2.8396
3/8	90.7627	81.3083	4.3322	3.5832	2.9407
7/16	92.3858	84.1777	4.3820	3.6250	3.0447
1/2	95.0334	87.1139	4.4330	3.6665	3.1509
9/16	97.2053	90.1175	4.4633	3.7080	3.2595
5/8	99.4021	93.1875	4.5337	3.7500	3.3706
11/16	101.6233	96.3304	4.5841	3.7913	3.4843
3/4	103.8691	99.5412	4.6345	3.8330	3.6004
13/16	106.1394	102.8225	4.6848	3.8750	3.7191
7/8	108.4342	106.1754	4.7352	3.9163	3.8404
15/16	110.7536	109.5973	4.7856	3.9580	3.9641
6 *in.*	113.0976	113.0976	4.8360	4.0000	4.0907
1/16	115.4660	116.6688	4.8863	4.0417	4.2200
1/8	117.8590	120.3139	4.9367	4.0833	4.3517
3/16	120.2771	124.0374	4.9871	4.1250	4.4874
1/4	122.7187	127.8320	5.0375	4.1666	4.6236
5/16	125.1852	131.7053	5.0878	4.2083	4.7638
3/8	127.6765	135.6563	5.1382	4.2500	4.9067
7/16	130.1923	139.6854	5.1886	4.2917	5.0524
1/2	132.7326	143.7936	5.2390	4.3332	5.2010
9/16	135.2974	147.9815	5.2893	4.3750	5.3525
5/8	137.8867	152.2499	5.3377	4.4165	5.5069
11/16	140.5006	156.5997	5.3901	4.4583	5.6786
3/4	143.1391	161.0315	5.4405	4.5000	5.8245
13/16	145.8021	167.5461	5.4908	4.5416	6.0601
7/8	148.4896	170.1682	5.5412	4.5832	6.1550
15/16	151.2017	174.8270	5.5916	4.6250	6.3235

Dia.	Surface.	Solidity.	Cube.	Cylinder.	Water in lbs.
7 in.	153.9384	179.5948	5.6420	4.6665	6.4960
1/16	156.6995	184.4484	5.6923	4.7082	6.6725
1/8	159.4852	189.3882	5.7427	4.7500	6.8502
3/16	162.2955	194.1165	5.7931	4.7915	7.0212
1/4	165.1303	199.5325	5.8435	4.8332	7.2171
5/16	167.9895	204.7371	5.8938	4.8750	7.4053
3/8	170.8735	210.0331	5.9442	4.9166	7.5970
7/16	173.7520	215.4172	5.9946	4.9582	7.7916
1/2	176.7150	220.8937	6.0450	5.0000	7.9897
9/16	179.6725	226.7240	6.0953	5.0415	8.2006
5/8	182.6545	232.1235	6.1457	5.0832	8.3960
11/16	185.6611	237.8883	6.1961	5.1250	8.6044
3/4	188.6923	243.7276	6.2465	5.1665	8.8157
13/16	191.7480	249.4720	6.2968	5.2082	9.0234
7/8	194.8282	255.7121	6.3472	5.2500	9.2491
15/16	197.9330	261.9673	6.3976	5.2913	9.4753
8 in.	201.0624	268.0632	6.4480	5.3330	9.6965
1/16	204.2162	274.4156	6.4983	5.3750	9.9260
1/8	207.3946	280.8469	6.5487	5.4164	10.1583
3/16	210.5976	287.3780	6.5991	5.4581	10.3944
1/4	213.8251	294.0095	6.6495	5.5000	10.6343
5/16	217.0770	300.7422	6.6998	5.5414	10.8778
3/8	220.3537	307.5771	6.7502	5.5831	11.1250
7/16	223.6549	314.5147	6.8006	5.6250	11.3760
1/2	226.9806	321.5553	6.8510	5.6664	11.6306
9/16	230.3308	328.7012	6.9013	5.7080	11.8891
5/8	233.7055	335.9517	6.9517	5.7500	12.1514
11/16	237.1048	343.3079	7.0021	5.7913	12.4170
3/4	240.5287	350.7710	7.0525	5.8330	12.6874
13/16	243.9771	358.3412	7.1028	5.8750	12.9612
7/8	247.4500	366.0199	7.1532	5.9163	13.2390
15/16	250.9475	373.8073	7.2036	5.9580	13.5206
9 in.	254.4696	381.7017	7.2540	6.0000	13.8062
1/16	258.0261	389.7118	7.3043	6.0417	14.0959
1/8	261.5872	397.8306	7.3547	6.0833	14.3895
3/16	265.1829	406.0613	7.4051	6.1250	14.6872
1/4	268.8031	414.4048	7.4555	6.1667	14.9890
5/16	272.4477	421.2907	7.5058	6.2083	15.2381
3/8	276.1171	431.4361	7.5562	6.2500	15.6050
7/16	279.8110	440.1294	7.6066	6.2916	15.9195
1/2	283.5294	448.9215	7.6570	6.3333	16.2375
9/16	287.2723	457.8500	7.7073	6.3750	16.5604
5/8	291.0397	466.8763	7.7577	6.4166	16.6869
11/16	294.8310	476.0304	7.8081	6.4582	17.2180
3/4	298.4483	485.3035	7.8585	6.5000	17.5534
13/16	302.4894	494.6952	7.9088	6.5415	17.8931
7/8	306.3550	504.2094	7.9592	6.5832	18.2373
15/16	310.9452	513.8436	8.0096	6.6250	18.5857

Dia.	Surface.	Solidity.	Cube.	Cylinder.	Water in lbs.
10 *in.*	314.1600	523.6000	8.0600	6.6666	18.6786
1/16	318.0992	533.4789	8.1103	6.7083	19.2960
1/8	322.0630	543.4814	8.1607	6.7500	19.6577
3/16	326.0514	553.6081	8.2111	6.7916	20.0240
1/4	330.0643	563.8603	8.2615	6.8333	20.3948
5/16	334.1016	574.2371	8.3118	6.8750	20.6682
3/8	338.1637	584.7415	8.3622	6.9166	21.1501
7/16	342.2503	595.3677	8.4126	6.9582	21.5344
1/2	346.3614	606.1318	8.4630	7.0000	21.9238
9/16	350.4970	617.0207	8.5133	7.0416	22.3176
5/8	354.6571	628.0387	8.5637	7.0833	22.7162
11/16	358.8418	639.1871	8.6141	7.1250	23.1194
3/4	363.0511	650.4666	8.6645	7.1666	23.5274
13/16	367.2849	661.8580	8.7148	7.2082	23.9394
7/8	371.5432	673.4222	8.7652	7.2500	24.3577
15/16	375.8261	685.0997	8.8156	7.2915	24.7801
11 *in.*	380.1336	696.9116	8.8660	7.3330	25.2073
1/16	384.4655	708.9106	8.9163	7.3750	25.6414
1/8	388.8220	720.9409	8.9667	7.4165	26.0764
3/16	393.2031	733.1599	9.0171	7.4582	26.5184
1/4	397.6087	745.5004	9.0675	7.5000	26.5657
5/16	402.0387	758.0104	9.1178	7.5414	27.4162
3/8	406.4935	770.6440	9.1682	7.5832	27.8742
7/16	410.7728	783.5787	9.2186	7.6250	28.3420
1/2	415.4766	796.3301	9.2690	7.6664	28.8033
9/16	420.0049	809.3944	9.3193	7.7080	29.2754
5/8	424.5576	822.5807	9.3697	7.7500	29.7527
11/16	429.1351	835.9695	9.4201	7.7913	30.2370
3/4	433.7371	849.4035	9.4705	7.8330	30.7229
13/16	438.3636	863.0283	9.5208	7.8750	31.2157
7/8	443.0146	876.7999	9.5772	7.9163	31.3883
15/16	447.6902	890.7070	9.6216	7.9580	32.2169
12 *in.*	452.3904	904.7808	9.6720	8.0000	32.7259
1/4	471.4363	962.5158	9.8735	8.1666	34.8142
1/2	490.8750	1022.656	10.0750	8.3332	36.9886
3/4	506.7064	1085.251	10.2765	8.5000	39.2535
13 *in.*	530.9304	1150.337	10.4780	8.6666	41.6077
1/4	551.5471	1218.000	10.6790	8.8332	44.0551
1/2	572.5566	1288.252	10.8810	9.0000	46.5961
3/4	593.9587	1361.346	11.0825	9.1665	49.2399
14 *in.*	615.7536	1436.758	11.2840	9.3332	51.9675
1/4	637.9411	1515.106	11.4855	9.5000	54.8014
1/2	660.5214	1596.260	11.6870	9.6665	57.7367
3/4	683.4943	1680.265	11.8885	9.8332	60.7751
15 *in.*	706.8600	1767.150	12.0900	10.0000	64.0178
1/4	730.6183	1856.988	12.2915	10.1666	67.1672
1/2	*754.7694*	*1949.821*	12.4930	10.3332	70.5250
3/4	*779.3131*	2045.697	12.6940	10.5000	73.9929
16 *in.*	*804.2496*	2144.665	12.8960	10.6666	77.5725

TABLE OF RECIPROCALS

FOR OBTAINING DECIMAL EQUIVALENTS.

No.	Recip.	No.	Recip.	No.	Recip.	No.	Recip.	No.	Recip.
1	1.000000	51	.019607	101	.009900	151	.006623	201	.004975
2	.500000	52	.019231	102	.009803	152	.006579	202	.004951
3	.333333	53	.018868	103	.009709	153	.006536	203	.004927
4	.250000	54	.018519	104	.009616	154	.006494	204	.004901
5	.200000	55	.018182	105	.009523	155	.006451	205	.004879
6	.166667	56	.017857	106	.009433	156	.006411	206	.004855
7	.142857	57	.017543	107	.009345	157	.006370	207	.004831
8	.125000	58	.017242	108	.009260	158	.006329	208	.004807
9	.111111	59	.016949	109	.009174	159	.006290	209	.004785
10	.100000	60	.016667	110	.009091	160	.006250	210	.004762
11	.090901	61	.016393	111	.009010	161	.006211	211	.004740
12	.083333	62	.016129	112	.008928	162	.006172	212	.004716
13	.076923	63	.015873	113	.008850	163	.006135	213	.004695
14	.071428	64	.015625	114	.008771	164	.006097	214	.004673
15	.066667	65	.015385	115	.008695	165	.006061	215	.004651
16	.062500	66	.015151	116	.008620	166	.006025	216	.004629
17	.058823	67	.014925	117	.008548	167	.005988	217	.004609
18	.055556	68	.014705	118	.008475	168	.005952	218	.004589
19	.052632	69	.014492	119	.008403	169	.005917	219	.004566
20	.050000	70	.014285	120	.008333	170	.005882	220	.004546
21	.047620	71	.014085	121	.008264	171	.005847	221	.004525
22	.045455	72	.013889	122	.008196	172	.005813	222	.004505
23	.043078	73	.013698	123	.008130	173	.005781	223	.004485
24	.041667	74	.013513	124	.008065	174	.005748	224	.004465
25	.040000	75	.013333	125	.008000	175	.005715	225	.004444
26	.038462	76	.013158	126	.007936	176	.005682	226	.004425
27	.037038	77	.012997	127	.007875	177	.005650	227	.004406
28	.035715	78	.012820	128	.007812	178	.005618	228	.004386
29	.034483	79	.012659	129	.007752	179	.005586	229	.004366
30	.033333	80	.012500	130	.007693	180	.005556	230	.004348
31	.032259	81	.012346	131	.007634	181	.005524	231	.004329
32	.031250	82	.012195	132	.007576	182	.005495	232	.004311
33	.030303	83	.012048	133	.007519	183	.005464	233	.004292
34	.029412	84	.011904	134	.007463	184	.005434	234	.004273
35	.028572	85	.011765	135	.007408	185	.005406	235	.004256
36	.027778	86	.011628	136	.007352	186	.005376	236	.004238
37	.027028	87	.011494	137	.007299	187	.005347	237	.004220
38	.026316	88	.011364	138	.007247	188	.005320	238	.004201
39	.025642	89	.011235	139	.007195	189	.005292	239	.004184
40	.025000	90	.011111	140	.007143	190	.005264	240	.004167
41	.024390	91	.010989	141	.007093	191	.005235	241	.004150
42	.023809	92	.010870	142	.007042	192	.005208	242	.004132
43	.023255	93	.010753	143	.006994	193	.005182	243	.004116
44	.022727	94	.010639	144	.006944	194	.005155	244	.004098
45	.022222	95	.010527	145	.006896	195	.005129	245	.004081
46	.021739	96	.010417	146	.006850	196	.005102	246	.004065
47	.021276	97	.010310	147	.006802	197	.005076	247	.004048
48	.020833	98	.010204	148	.006756	198	.005051	248	.004033
49	.020408	99	.010101	149	.006712	199	.005025	249	.004016
50	.020000	100	.010000	150	.006667	200	.005000	250	.004000

The numbers in the table are the denominators of the fraction, hence, multiply the reciprocal of the denominator by the numerator of the fraction, and the product is the decimal equivalent.

Thus, suppose the decimal equivalent of 7-16 be required,

Reciprocal of 16 = .0625 × 7 = .4375 its decimal equivalent.

TABLE

CONTAINING

THE WEIGHT OF COLUMNS OF WATER,

EACH ONE FOOT IN LENGTH,

AND OF VARIOUS DIAMETERS,

IN LBS. AVOIRDUPOIS.

Dia.	Weight.	Dia.	Weight.	Dia.	Weight.
3 *in.*	3.0672	9 *in.*	27.6120	15 *in.*	76.7004
⅛	3.3288	⅛	28.3848	⅛	77.9844
¼	3.6000	¼	29.1672	¼	79.2792
⅜	3.8820	⅜	29.9604	⅜	80.5836
½	4.1748	½	30.7656	½	81.9000
⅝	4.4784	⅝	31.6524	⅝	83.2260
¾	4.7928	¾	32.4060	¾	84.5628
⅞	5.1180	⅞	33.2424	⅞	85.9104
4 *in.*	5.4540	10 *in.*	34.0884	16 *in.*	87.2688
⅛	5.7996	⅛	34.9464	⅛	88.6368
¼	6.1572	¼	35.8152	¼	90.0168
⅜	6.5244	⅜	36.6936	⅜	91.4176
½	6.9024	½	37.5828	½	92.8080
⅝	7.2912	⅝	38.4828	⅝	94.2192
¾	7.6908	¾	39.3936	¾	95 6412
⅞	8.1012	⅞	40.3152	⅞	97.0740
5 *in.*	8.5212	11 *in.*	41.2476	17 *in.*	98 5176
⅛	8.9532	⅛	42.1908	⅛	99.9720
¼	9.3948	¼	43.1436	¼	101.4372
⅜	9.8484	⅜	44.1084	⅜	102.9120
½	10.3126	½	45.0828	½	104.3988
⅝	10.7856	⅝	46.0680	⅝	105.8952
¾	11.2704	¾	47.0640	¾	107.4024
⅞	11.7660	⅞	48.0708	⅞	108.9204
6 *in.*	12.2712	12 *in.*	49.0884	18 *in.*	110.4492
⅛	12.7884	⅛	50.1168	⅛	111.9888
¼	13.3152	¼	51.1548	¼	113.5392
⅜	13.8540	⅜	52.2048	⅜	115.0992
½	14.4024	½	53.2644	½	116.6712
⅝	14.9616	⅝	54.3348	⅝	118.2528
¾	15.5316	¾	55.4760	¾	119.8452
⅞	16.1124	⅞	56.4804	⅞	121.4484
7 *in.*	16.7028	13 *in.*	57.6108	19 *in.*	123.0624
⅛	17.3052	⅛	58.7244	⅛	124.6872
¼	17.9172	¼	59.8476	¼	126.3228
⅜	18.5412	⅜	60.9828	⅜	127.9680
½	19.1748	½	62.1276	½	129.6252
⅝	19.8192	⅝	63.2832	⅝	131.5320
¾	20.4744	¾	64.4496	¾	132.9696
⅞	21.1404	⅞	65.6268	⅞	134.6580
8 *in.*	21.8172	14 *in.*	66.8148	20 *in.*	136.3562
⅛	22.5036	⅛	68.0136	⅛	138.0672
¼	23.2020	¼	69.2220	¼	139.7880
⅜	23.9100	⅜	70.4424	⅜	141.5194
½	24.5288	½	71.6724	½	143.2608
⅝	25.3524	⅝	72.9120	⅝	145.0128
¾	26.0988	¾	74.1648	¾	146.7756
⅞	26.8500	⅞	75.4272	⅞	148.5492

Dia.	Weight.	Dia.	Weight.	Dia.	Weight.
21 *in.*	150.2376	27 *in.*	248.5116	33 *in.*	371.2344
⅛	152.1288	⅛	250.8180	⅛	374.0520
¼	153.9348	¼	253.1352	¼	376.8004
⅜	155.7396	⅜	255.4632	⅜	379.4592
½	157.5780	½	257.8008	½	382.5684
⅝	159.4152	⅝	260.1504	⅝	385.4292
¾	161.2644	¾	262.5096	¾	388.2996
⅞	163.1220	⅞	264.8796	⅞	391.1820
22 *in.*	164.9928	28 *in.*	267.2616	34 *in.*	394.0740
⅛	166.8732	⅛	269.6532	⅛	396.9768
¼	168.7632	¼	272.0544	¼	399.8928
⅜	170.6652	⅜	275.6672	⅜	402.8088
½	172.5780	½	276.8916	½	405.7500
⅝	174.5004	⅝	279.3252	⅝	408.6948
¾	176.4336	¾	281.7708	¾	411.4116
⅞	178.3776	⅞	284.2260	⅞	414.6180
23 *in.*	180.3324	29 *in.*	286.6920	35 *in.*	417.5952
⅛	182.2980	⅛	289.1688	⅛	420.5844
¼	184.2744	¼	291.6564	¼	423.5832
⅜	186.2616	⅜	294.1548	⅜	426.5928
½	188.2584	½	296.5543	½	429.6120
⅝	190.2672	⅝	299.1828	⅝	432.6432
¾	192.2856	¾	301.7124	¾	435.6840
⅞	194.3184	⅞	304.2540	⅞	438.7368
24 *in.*	196.3548	30 *in.*	306.8052	36 *in.*	441.7992
⅛	198.4056	⅛	309.3672	¼	447.9573
¼	200.4672	¼	311.9400	½	454.1678
⅜	203.5384	⅜	314.5224	¾	460.4105
½	204.6216	½	317.1168	37 *in.*	466.6960
⅝	206.7144	⅝	319.7220	¼	473.0240
¾	208.8192	¾	322.3368	½	479.3946
⅞	210.9336	⅞	324.9624	¾	485.8078
25 *in.*	213.0588	31 *in.*	327.6000	38 *in.*	492.2637
⅛	215.1948	⅛	330.2472	¼	498.7621
¼	217.3416	¼	332.9052	½	505.3032
⅜	219.4980	⅜	335.5728	¾	511.9979
½	221.6664	½	338.2524	39 *in.*	518.4132
⅝	223.8444	⅝	340.9428	¼	525.1821
¾	226.0344	¾	343.6428	½	531.8936
⅞	228.2340	⅞	346.3536	¾	538.6478
26 *in.*	230.4444	32 *in.*	349.0764	40 *in.*	545.4445
⅛	232.6644	⅛	351.8088	¼	552.2839
¼	234.8576	¼	354.5520	½	559.1659
⅜	237.1404	⅜	357.3048	¾	566.0904
½	239.3928	½	360.0696	41 *in.*	573.0577
⅝	*241.6572*	⅝	362.8452	½	587.1199
¾	*243.9312*	¾	365.6304	42 *in.*	601.3526
⅞	*246.2160*	⅞	368.4276	50 *in.*	799.2426

The preceding tables are rendered of great utility by means of the following :—

The weight of	Water	being	1.
The weight of	Copper	=	8.8
———	Brass	=	8.4
———	Iron, cast	=	7.2
———	Lead	=	11.3
———	Zinc	=	7.2
———	Gun metal	=	8.7
———	Sand	=	1.5
———	Coal	=	1.25
———	Brick	=	2.0
———	Stone	=	2.5
———	Timber, average	=	0.85

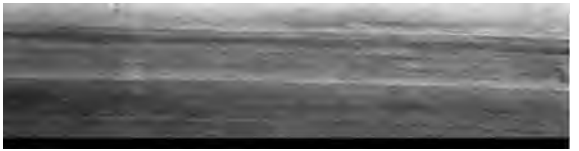
Example.—Suppose it be required to ascertain the weight of a cast iron pipe $26\frac{1}{4}$ inches outside and $23\frac{3}{4}$ inside, the length being $6\frac{1}{2}$ feet.

Opposite $26\frac{1}{4}$ in the table is
$234.8576 \times 7.2 \times 6.5 = 10991.135$
And opposite $23\frac{3}{4}$ in the table is
$192.2856 \times 7.2 \times 6.5 = 8998.966$ subtract
1992.169 lbs. Avs.

And in a similar manner the weight of a column or pipe of another material can easily be obtained.

EGERTON SMITH AND CO., PRINTERS, LIVERPOOL.

Weight.	Dia.	Weight.	Dia.	Weight.
150.2376	27 *in.*	248.5116	33 *in.*	371.2344
152.1288	⅛	250.8180	⅛	374.0520
153.9348	¼	253.1352	¼	376.8004
155.7396	⅜	255.4632	⅜	379.4592
157.5780	½	257.8008	½	382.5684
159.4152	⅝	260.1504	⅝	385.4292
161.2644	¾	262.5096	¾	388.2996
163.1220	⅞	264.8796	⅞	391.1820
164.9928	28 *in.*	267.2616	34 *in.*	394.0740
166.8732	⅛	269.6532	⅛	396.9768
168.7632	¼	272.0544	¼	399.8928
170.6652	⅜	275.6672	⅜	402.8088
172.5780	½	276.8916	½	405.7500
174.5004	⅝	279.3252	⅝	408.6948
176.4336	¾	281.7708	¾	411.4116
178.3776	⅞	284.2260	⅞	414.6180
180.3324	29 *in.*	286.6920	35 *in.*	417.5952
182.2980	⅛	289.1688	⅛	420.5844
184.2744	¼	291.6564	¼	423.5832
186.2616	⅜	294.1548	⅜	426.5928
188.2584	½	296.5543	½	429.6120
190.2672	⅝	299.1828	⅝	432.6432
192.2856	¾	301.7124	¾	435.6840
194.3184	⅞	304.2540	⅞	438.7368
196.3548	30 *in.*	306.8052	36 *in.*	441.7992
198.4056	⅛	309.3672	¼	447.9573
200.4672	¼	311.9400	½	454.1678
203.5384	⅜	314.5224	¾	460.4105
204.6216	½	317.1168	37 *in.*	466.6960
206.7144	⅝	319.7220	¼	473.0240
208.8192	¾	322.3368	½	479.3946
210.9336	⅞	324.9624	¾	485.8078
213.0588	31 *in.*	327.6000	38 *in.*	492.2637
215.1948	⅛	330.2472	¼	498.7621
217.3416	¼	332.9052	½	505.3032
219.4980	⅜	335.5728	¾	511.9979
221.6664	½	338.2524	39 *in.*	518.4132
223.8444	⅝	340.9428	¼	525.1821
226.0344	¾	343.6428	½	531.8936
228.2340	⅞	346.3536	¾	538.6478
230.4444	32 *in.*	349.0764	40 *in.*	545.4445
232.6644	⅛	351.8088	¼	552.2839
234.8576	¼	354.5520	½	559.1659
237.1404	⅜	357.3048	¾	566.0904
239.3928	½	360.0696	41 *in.*	573.0577
241.6572	⅝	362.8452	½	587.1199
243.9312	¾	365.6304	42 *in.*	601.3526
246.2160	⅞	368.4276	50 *in.*	799.2426



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